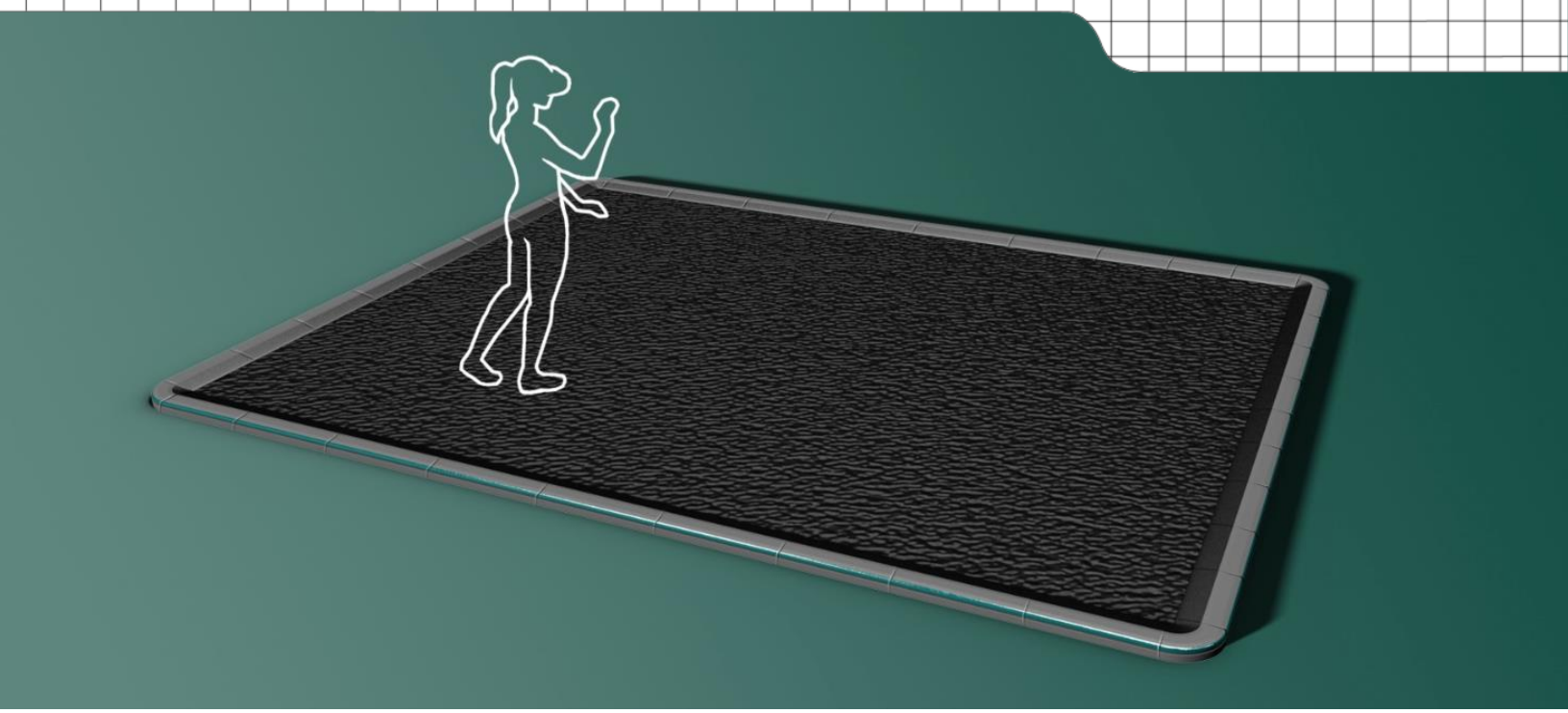
CHALMERS



Enhancing Virtual Reality experiences with feet haptics

Master of Science Thesis in the Master Degree Program, Industrial Design Engineering

FELICIA RÅNGE

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2017

Department of Product- and Production development
Division of Design & Human Factors

Master of Science Thesis

Enhancing Virtual Reality experiences with feet haptics

FELICIA RÅNGE

Examiner: Oskar Rexfelt

Supervisor: Daniel Sjölie and Oskar Rexfelt

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2017

Department of Product- and Production development
Division of Design & Human Factors

Master of Science Thesis PPUX05

Enhancing Virtual Reality experiences with feet haptics
Master of Science Thesis in the Master Degree Program, Industrial Design Engineering

Chalmers University of Technology
SE 412 96 Gothenburg, Sweden
Phone +46 (0) 31 - 772 1000

Cover photo: Visualization of the final concept design, made by Felicia Rånge.
Print: Repro Service Chalmers

Acknowledgements

This master thesis project was carried out together with the agency DigitasLBi, at its office located in Gothenburg. Being given the opportunity to do my master thesis in this cheerful environment has not only been inspiring, but also offered valuable insights. Therefore, I would like direct a big thank you to all employees at the Gothenburg office, and especially to Elin Kristell at DigitasLBi who has supported me through this project and given me very useful notes. To the Virtual Reality and Tech teams at DigitasLBi I also want to direct a special thanks for helping me, from answering all of my questions to helping me keep track of my post-its!

I would further like to express my appreciation to my examiner Oskar Rexfelt and supervisor Daniel Sjölie for the invaluable input on my work, which has been of great use. It is sometimes tricky to conduct a master thesis project alone due to the lock-in effects, but your feedback has really been helpful. For this purpose I would also like to express my appreciation to "my master thesis-colleague" Kajsa Blomberg, whom during this spring also have written her master thesis about user experience design in Virtual Reality, why we have been able to exchange input on each other's work from a close distance. Either if it have been swapping useful literature, reviewing ideas or keeping the spirits high, I am confident that this project would have been much more challenging without you.

The core of a user-centered project is the input from users, why I lastly would like to thank the participants of the surveys and user tests of this study. Additionally, I would also like to acknowledge the opponents, Moa Nybacka and Andrea Slaattelia Larsson, for your highly useful input on this report.

As this project marks the end of my studies, I want to dedicate this last section to my family and friends, and the endless support I received from you during these five years. Thank you!

Felicia Rånge
Gothenburg, 10th of July 2017

Abstract

This project was made for the digital communications and technology agency DigitasLBi, and studies on how user's experiences in Virtual Reality can be enhanced with haptics, and especially how feet haptics can be used for this purpose. Virtual Reality refers to the technology which simulates presence in a virtual world, while haptics are sensations of e.g. touch provided in human machine interactions. User experience and the design of this is an expression used with different meanings, but in this project this refers to the emotions and attitudes products elicits, which further affects the user's perception of the product experience. Thus, this project has treated user studies about how feet haptics enhances a specific virtual experience, but also studies about who the incoming users of this technology are, and how they differ from the current ones. To find the focus of this project, the trends and future implications regarding Virtual Reality was investigated to understand where this technology is heading, the expectations and the challenges. With the focus of being of use in the Virtual Reality activities of DigitasLBi, the outcome was general guidelines of experience design for Virtual Reality, and specific requirements regarding a feet haptic accessory for high-end Virtual Reality equipment. Lastly, the outcome was also a concept design of such an accessory, which offers an example to how the insights from this project can be applied.

Virtual Reality is surrounded by high expectations, due to the new possibilities of perceiving an embodied presence in any digitally manufactured environment. Since this just recently been realized of high quality in commercial products, the common challenge is creating meaningful and useful content. High-end products seem more likely to be of invaluable use in professional and business activities, than of a common public use. Here mobile Virtual Reality products are more likely to be used. As furthermore found in this study, the anticipations surrounding this futuristic technology has been important for stakeholders to generate funds of research - but now these pose a potential treat. This is due to that the incoming users characterizes by having high expectations on the quality and meaningfulness of the content, but holding a lower technology understanding and self-confidence. These concerns differ from those of the current users of early technology adopters, who both understand and affects the development of Virtual Reality products. Due to this, the current users sometimes overlook problems that the potential users might not. This is poses a risk for the future use of Virtual Reality, since design cues that are important to the future users might be overlooked by the creators.

The performed user study of a Virtual Reality experience that included passive feet haptics proved the increased immersion haptics offer. It was especially unveiled that while the feet are insensitive they are of great importance, due to them constantly being in contact with the ground. Thereby they unconsciously gives information about the surroundings and enhances the experience. As long as all virtual elements perceived as having similar visual qualities holds a consistency in their haptic design, the haptics does not have to be real life accurate to make sense to user. But, if this unconscious anticipation is broken, the user will be consciously aware and initiate a conscious evaluation of what is felt. When this results in a negative emotion, negative surprise or

unmasking how the haptics has been technically realized, the user will be taken out of presence which breaks the immersion. It was also expressed that Virtual Reality holds a promise of being real without turning too real, and incorporating haptics added to the latter. But since many Virtual Reality experiences rely on the immersion, and the unique property of feet haptics means offering an unconscious enhancement, there is great potential of feet haptics in experiences that relies on the function of presence.

Making use of the retrieved insights, the Virtual Reality mat was designed to be an generally useful accessory over various high-end experiences. By making use of passive haptics mat layer combinations, consistent and ambient impressions enhances the experience, while not making the experience turn uncomfortably realistic to the user. In addition to this, the in-complex construction and absence of inbuilt technology, means that its functionality is feasible to create for DigitasLBi – while offering a sustainable choice. Lastly, by making use of being a low fidelity concept and new design cues, the potential users of Virtual Reality will feel secure in use, as well as increasing their perception of feeling entitled to be users of this futuristic technology.

To summarize the contributions of this study that can be found in this report, they are the following (arranged in order of presentation in the report):

- Analysis of trends and future use of the Virtual Reality technology, and evaluations of the haptic need and feasibility for this purpose.
- Investigations on the current and incoming user groups, regarding differences and similarities in characteristics, considerations and expectations.
- User studies on how incorporating haptics affects the user experience.
- General user experience design guidelines and specific requirements for a feet haptic accessory for Virtual Reality.
- An exemplifying concept design of a feet haptic accessory being of use in the activities of DigitasLBi.

This report supports quick reading by each chapter ending with a short conclusion, which briefly summarizes what was presented in each chapter. A quick reading is here offered for those interested in the results of this project, but not having the time to read it all to get the key insights.

Keywords: Virtual Reality, user experience, haptics, sensory design, presence.

Words and definitions list

Augmented reality (AR)
enhancing real world experiences with digital elements

Augmented virtuality (AV)
enhancing digital experiences with real world elements

Congruence
what is perceived matches expectations and mental models

Cutaneous
the sensations of pressure, temperature and pain

Degrees of freedom (DOF)
the freedom of which the user can move in VR

Field of view (FOV)
the viewed area in VR which is available to see by the user

Guardian grid
a grid showing the limits of the virtual room in relation to the real room

Haptics
offering somesthetic sensations in human machine interactions

Haptic stimuli
the given somesthetic sensation in a human machine interaction

Head mounted display (HMD)
the headset used to simulate VR experiences

High-end VR
the VR products the offers the most realistic immersions into experiences

Immersion
the perception of being there in a virtual experience

Incongruence
what is perceived does not match expectations and mental models

Interdependency
that the human senses interact and updates what is perceived

Kinesthetic
the perception of motion and the positioning of limbs and body

Mixed reality (MR)
merging virtual and real worlds together in different extents

Mobile VR
products offering VR by relying on the capacity of a inserted smartphone

Passive haptics
using physical objects to realize haptics

Proprioception
the specific perception of the limbs and body's positioning in space

Somesthesis
the cutaneous, tactile, kinesthetic and proprioceptive sensations

Tactile
the perception of pressures, commonly called touch

Tracking
the technique of mapping real elements into VR

Unique selling point (USP)
the unique property or function differentiating a product

User experience (UX)
user's perception of product in terms of emotions and attitudes

User interface (UI)
the active and manipulable area of a product meeting the user

Virtual reality (VR)
the total immersion of a user into a digitally simulated world

Table of Contents

1

Introduction

1.1 Background

Virtual reality

As the expression suggests, Virtual Reality (hence referred to as VR) means the full immersion into a virtual environment via a simulator of some kind (Reality Technologies, 2016). VR itself is furthermore a subset of Mixed Reality (MR) technologies, which is also including Augmented Reality (AR) and Augmented Virtuality (AV). To get a notion about what these implies, a typical example of AR is e.g. Pokémon Go, referring to that virtual objects enhances the experience of the real environment. AV refers to being the other way around, when real world elements enhance the virtual experiences. The MR spectrum illustrates the relation between all these (seen in Figure 1), i.e. how real and virtual worlds can be merged together in various extents and ways (Kishino and Milgram, 1994).

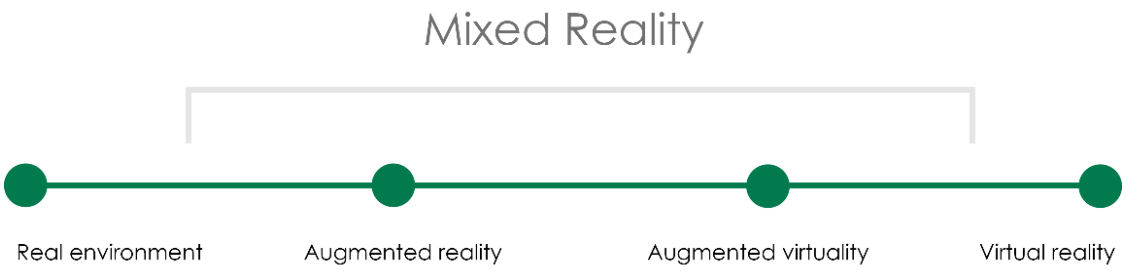


Figure 1 The Mixed Reality (MR) spectrum

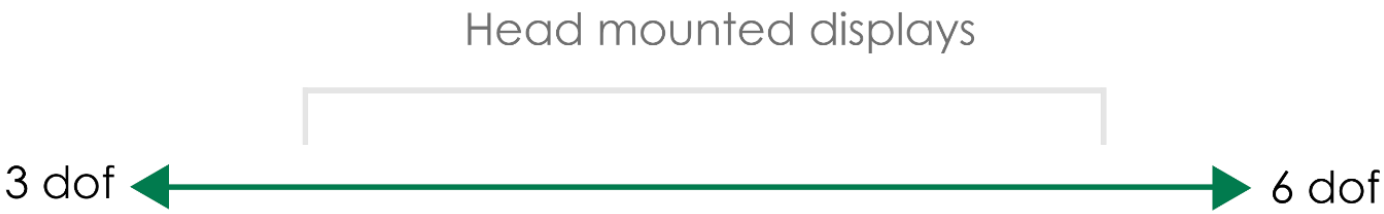


Figure 2 The span of degrees of freedom (DOF)

The idea of the functionality that the VR technology brings is nothing new, and has been widely portrayed in various science fiction medias for a long time e.g. The Matrix, The Lawnmower man and Minority Report. However, as recent technological progresses have been achieved, the VR technology have been put available commercially in an extent that was not possible with earlier products. The ratio of high fidelity differs in-between these products, mainly having to do with how the equipment is tracking the movements and positioning of the user into the visual and auditory virtual simulation. These tracking methods can be divided into three categories, that via different head mounted displays (HMD) furthermore offer different degrees of freedom (DOF) within the VR experience (Jaishanker, 2016).

Rotational tracking

Rotational tracking means that the HMD can sense how the user rotates the head in a xyz-space, often by using gyroscope or motion sensors. This means three DOF. Consequently, there is no possibility to e.g. walk or jump in VR, but it is common having some kind of hand control to offer a teleportation in VR. Examples of such products are Samsung Gear VR, Google Cardboard and Google Daydream, seen in Figure 3. The functionality of all these depends on inserting a smartphone, i.e. mobile VR, which is the common technique for when only providing three DOF.

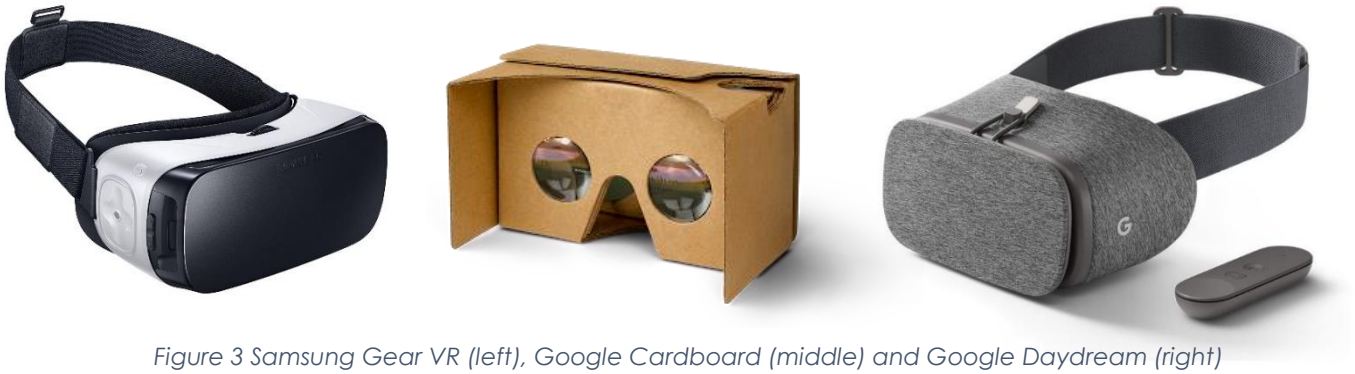


Figure 3 Samsung Gear VR (left), Google Cardboard (middle) and Google Daydream (right)

Positional tracking

Positional tracking refers to that the HMD tracks how the head moves within the xyz-space, meaning that kneeling, jumping and leaning forward is possible. For all of the current products, a hand held control is included, and to track the user's moves an external device is commonly used, i.e. some kind of sensor as a camera. Again, only using positional tracking is three DOF, why this still means that the user cannot actually walk around freely in the virtual 3D space. A product example is the first commercial product of Oculus Rift, which also makes use of rotational tracking (the newest version of similar measures seen Figure 4).

Figure 4 The Oculus Rift equipment, showing two types of controllers, a tracking camera and the HMD.

Room-scale tracking

Allows the user to walk around and move however preferred, though within fixed pre-determined virtual space that is mapped against a room space in the real world. How the user is positioned in this space is determined by using external sensors that are strategically placed out in the real room. These sensors are communicating with the HMD and the hand held controllers to register the moves of the users. Room-scale tracking means using both positional and rotational tracking techniques to offer this experience, and thereby holds six DOF. Product examples currently dominating the market of what makes high-end VR, are Oculus Rift and HTC Vive (Figure 5). The PlayStation VR is also available (Figure 5), however not yet competing in the dominance of high-end VR.

Figure 5 The HTC Vive equipment (top) and the PlayStation VR equipment (below), each showing the HMDs, hand controllers and tracking devices

In addition to these, there are product accessories to the basic VR equipment, often coming in terms of different types of input controllers of various designs. Some are offering what is called haptics, meaning that the human machine interactions generate sensory impressions in terms of pressure, temperature, pain, movements, motion and position in space (El Saddik et. al., 2011). A few are offering haptics as the main focus, however none is offering a full and entirely real world accurate experience. Accessories to VR are currently being introduced in a fast pace, especially since the popularity increases since

the technology is turning more and more of a hot topic. Some accessories are available commercially, while many are startup projects that has yet to be launched commercially (Painter, 2017). Most of these accessories are adapted to a certain use case, mainly being gaming experiences. To get a more specific overview what types of accessories that are currently available, the condensed properties held by the various accessories are here briefly presented.

Hand input gesture trackers

By tracking hand and finger movements in different ways, products as e.g. Gloveone and Leap Motion makes gesturing and interaction possible without handheld controls (Figure 6). Gloveone is specialized for VR and offers haptic feedback, while Leap Motion, and similar products, were not originally developed for VR, but are increasingly gaining usefulness for the VR medium.

Figure 6 Gloveone smart gloves and the Leap Motion gesture tracker.

Body movement control

Products as e.g. Virtuix Omni and Cyberith Virtualizer are treadmill-like platforms that offer the user to move in VR without moving in real world space (Figure 7). A similar product variant is Roto VR, being a chair that rotates similarly to where the user looks, and has inbuilt feet controls that simulates walking in VR while sitting down in the real world (Figure 7).

Figure 7 Virtuix Omni (left) Cyberith Virtualizer (middle) and Roto VR (right).

Haptic feedback

While tracking input devices as gloves and hand controls sometimes offers haptic feedback, there are specific products stimulating other body areas with haptic, e.g. the Feelreal mask, Teslasuit and Cerevo Taclim shoes (Figure 8). The Feelreal mask is added to the HMD and simulates haptic effects as moisture, temperature, air movement and vibrations, but also some scents. Teslasuit and Cerevo Taclim shoes simulates haptic experiences via vibrations, where vibrations are the most common execution of haptics. Teslasuit applies to torso, arms and legs, while Cerevo Taclim applies to the feet as well as offering tracking of the feet.

Figure 8 Feelreal mask (left), Teslasuit (middle) and Cerevo Taclim shoes (right).

The technology of VR develops in a fast pace, making simulations of any experience possible to perform technically. Therefore insights about user experience design are now possible to be discovered as developers takes the quality of software's even further. Even though there are some ideas and research about this area, a lot is yet to be discovered when speaking about how to design experiences. This is especially the case for experiences not being visual or auditory, as this is where the focus of development naturally has been put previously.

Due to the immense interest all subjects related to the topic of VR brings, the interest of haptics to VR is increasing, why more and more haptic product accessories are emerging. Previous studies has pressed the importance of haptics in virtual environments (Robles-De-La-Torre, 2006), but also that haptics enhances the immersion into the virtual experience to a significant extent, meaning the sense of being in there (Insko, 2001). Via a study of a task training experience in VR, Insko also proved that not only did haptics increase the users' understanding and learning from the virtual experience, but also that

they would bring this learning out of the virtual experience to increase their performance in similar real life task. Due to the affecting qualities VR haptics bring, there is therefore a need of insights about how to design haptic impressions for VR from a user experience (UX) point of view. User experience design for this purpose consequently means how the haptic input affects the perception of the VR experience from the targeted user's point of view. Such insights also refers to understanding what kind of general haptic impressions that should be given, in relation to how these affect the user's perception and performance within the experience. As this has to do with who the users are, designing user experiences also refers to learning about who the current and incoming users of VR are, to understand what the target group actually want to experience in VR and thereby reach a greater VR experience.

DigitasLBi

DigitasLBi is a communication and technologies agency, working internationally with business organizations to make use of the possibilities offered in the digital world. At the office of DigitasLBi in Gothenburg, digital experiences are designed and created to further achieve this, in terms of what is suitable for their customer's business idea or product concept. Among several departments, there are the User Experience Department and Virtual Reality Department, working in this area of creating digital products. Examples of such digital products from these departments' portfolios are product showrooms for Volvo Cars and OnePlus (Figure 9), as well as Husqvarna's VR chainsaw game.

DigitasLBi

Figure 9 OnePlus the Loop, a VR experience created by DigitasLBi.

More and more companies are approaching DigitasLBi requesting VR solutions, a consequence of the increased public interest in VR-solutions. The experiences requested by the customers come in a wide span of different VR solutions, such as VR-simulators to change behaviors in dangerous environments or product launch showrooms. Though, there are some common denominators regarding the customer, the experience and the users of these, which are presented in Table 1. For some of these experiences haptic input is requested, commonly being passive haptics, which by Insko is defined by "augmenting a high-fidelity visual virtual environment with low-fidelity physical objects". For this purpose DigitasLBi has an interest in receiving general insights regarding VR experiences design, from a user point of view understand how the users interact with and respond to the experience, but also how to design haptic input in VR for this purpose. Consequently, research and guidelines describing these insights are sought after, furthermore describing how the user experience could be enhanced by haptics to offer amplified and greater user experiences.

Table 1. Characteristics of the VR commissions of DigitasLBi.

CUSTOMER	WHY	WHAT	USERS
Identified VR as useful for their brand and products Resources and interest to invest in a VR solution	To establish the customer's brand and products among users Identified to add value for customer and user Best and most useful technique for the task	Brand activities e.g. showrooms, events and games Suitable for and supporting the customer's brand and products For a specific use case Experiences of shorter use time cycles	Anyone targeted by the customers for the use case Gets in contact with VR use case areas Same as the soon-to-be users of commercial VR, due to the wide range of customers Observed as first-time or unexperienced users that are tech-oriented

Sustainability and Virtual Reality

The technology of creating any experience virtually means both possibilities and disadvantages in terms of sustainability, where a sustainability is defined according to the framework seen in Table 2 (The Natural Step, 2016). VR by itself offers possibilities to create deepened understanding and learning, but also working and travelling. This means a great potential to use VR in educating about our common sustainability challenges, but also innovating the way we are travelling through reducing unnecessary travels (HTC Vive, 2017). However, the VR technology by itself relies on powerful computers or smartphones, which requires a lot of energy to fuel. This means that the source of energy is vital for whether VR will be sustainable or not (Sustainable Virtual Design, 2016). Additionally, a constant sustainability aspect of all technology of this kind is the use of critical metals and minerals, which might, or might not, be mined during unethical circumstances.

Table 2 The sustainability framework of the Natural Step.

IN A SUSTAINABLE SOCIETY, NATURE IS NOT SUBJECT TO…			
1	**2**	**3**	**4**
Systematically increasing concentrations of substances from the earth's crust, such as fossil CO2 and heavy metals	Systematically increasing concentrations by society, such as antibiotics and endocrine disruptors.	Systematically increasing degradation by physical means, such as deforestation and draining of groundwater tables.	In that society, there are no structural obstacles to people's health, influence, competence, impartiality and meaning.

As for this master thesis project, sustainability will primary be a criteria of concept development and evaluation. However, sustainability will also be included in terms of the ethics that follows with the possibilities of being able to do and experience anything and everything via VR. Additionally, potential downsides has to be balanced against the possibilities that might be supported, e.g. that the consumption of (sustainable) energy could be acceptable if a popular use of VR could lead to humans travelling more sustainable.

1.2 Project formulation

Task

The task of this master thesis project is to investigate how haptic input can be used to create another dimension of user experiences in VR, and what this means from the potential VR users point of view. This means investigating how haptic VR experiences are perceived and designed from a user perspective. The outcome of greatest interest for DigitasLBi is the insights and knowledge from the research. Compiled into general user experience guidelines and requirements for a haptic VR accessory design, these are the sought after outcome of this project, together with the report and project presentation, which will be of use for the Virtual Reality and User Experience Departments of DigitasLBi.

The innovative accessory is to offers insights into what a product could look like that implements the insights of this study, as developing physical products of this kind normally is not included in the activities of DigitasLBi. Nevertheless, depending on the qualities of this concept design, it shall not be excluded that the concept could be of use in an upcoming project at DigitasLBi. This means that the concept must hold feasibility of being generally useable in several areas of likely future VR use, as the futuristic approach has to do with if DigitasLBi could make any use of this solution in their upcoming activities.

Purpose

The aim of this master thesis project is to generally investigate how the user experience in VR takes place, and how the experience can be enhanced and affected by haptics, from a user centered point of view. Since the current VR technology is relatively new and unexplored, means that the possibilities now opens up to investigate what role haptics can play for the user experience in VR. Consequently, all knowledge about user perception, interaction and experience in VR is of great value at this point. Founded on the research regarding the haptic influence on VR experiences, a haptic concept of a VR accessory shall be designed, which is being of general use. The concept shall work to haptic wise enhance the experiences of DigitasLBi today, as well the potential ones of the future 5 years.

Scope

To reach the aim of this project, general user experience design guidelines and specific requirements for haptics has to be investigated, serving as the foundation for the concept design. To create these, insights must be gathered about what impressions that are sought after and not, in order to reach a greater experience. Consequently, the users point of view of VR experiences with haptics to be researched. To narrow down the research, a specific body area of haptic focus is to be identified early on, based on the implications of future use of high-end VR. The resulting concept design is to serve as an example of how these insights can be implemented, rather than actually being intended to be manufactured. This means that no specific timeframe is set for the concept entering the market, but rather depends on the upcoming future activities of DigitasLBi.

Question formulation

- What body area should be enhanced by haptics, in which extent, how and with greatest success, in order to reach a suitable level of immersion from a user experience point of view?
- What does a greater and better VR experience translate to from a user experience point of view, and what role can haptics play here?
- How can haptics be used in VR in a design that is generally applicable to several cases of use of both current and future qualities of DigitasLBi's experiences?

Delimitations

- No programming or software composition will be included in this project as outcome.
- The research will focus on enhancing high-end VR experiences, which are provided by HMDs using six DOF.
- Apply not only to the current users of VR, but rather the potential target group of the soon-to-come users of VR, due to that the users of DigitasLBi's VR experiences has to do with whom their customers wants to direct to.
- Not primarily focus on motivating what haptics should be used for in VR, or a specific experience example, but rather focus on what haptics in VR generally mean for the user's experience and performance.

Project process

This project will generally follow the Double Diamond design process model, which means the four phases of Discover, Define, Develop and Deliver (Design Council, 2007). Due to that the greatest weight of this project is put upon the research of the implications of haptics on VR experience from a user point of view, the phases of Discover and Define is where most resources will be put in relation to the two following phases. As seen in Figure 10, the otherwise symmetric Double Diamond design process model has been modified to illustrate this. In addition, the project process will also be influenced by the Design for Emotion approach, referring to a systematic approach to designing emotional user experiences (van Boejien, 2013).

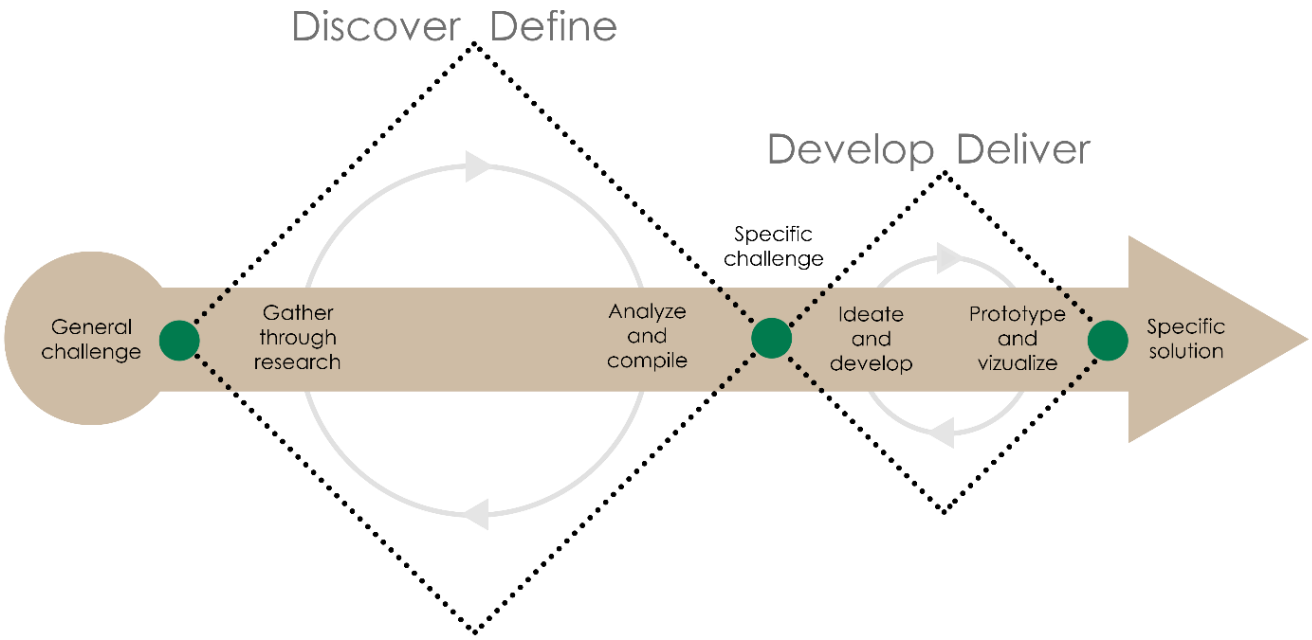


Figure 10 The project process, based on the Double Diamond design model.

The project phases are here described, followed by a Gantt-schedule describing the distribution specific project activities versus time (Figure 11).

Discover

Investigate via literature studies and user research how the user experiences in VR are generally affected by haptics. To early determine which body area to focus the further haptic research upon, a pre-study consisting of literature studies, trend analysis and future predictions will be key.

Define

Create general guidelines and requirements for experience design in VR that indicates how haptic experiences should be designed for the identified body area. These shall be based upon an identification of what the haptic impressions means for the experience, as well which haptic experiences that should be given for the identified body area. Lastly, these guidelines and requirements will shed insights on what haptic properties, and how, that are suitable to enhance in a general concept design.

Develop

Idea generation on a haptic VR accessory that offers the right experiences weighted against the activities of DigitasLBi and sustainability.

Deliver

Visual representations of a relatively innovative haptic concept design which generally enhances the immersion of VR experiences, with the possibility of being useful in the activities of DigitasLBi.

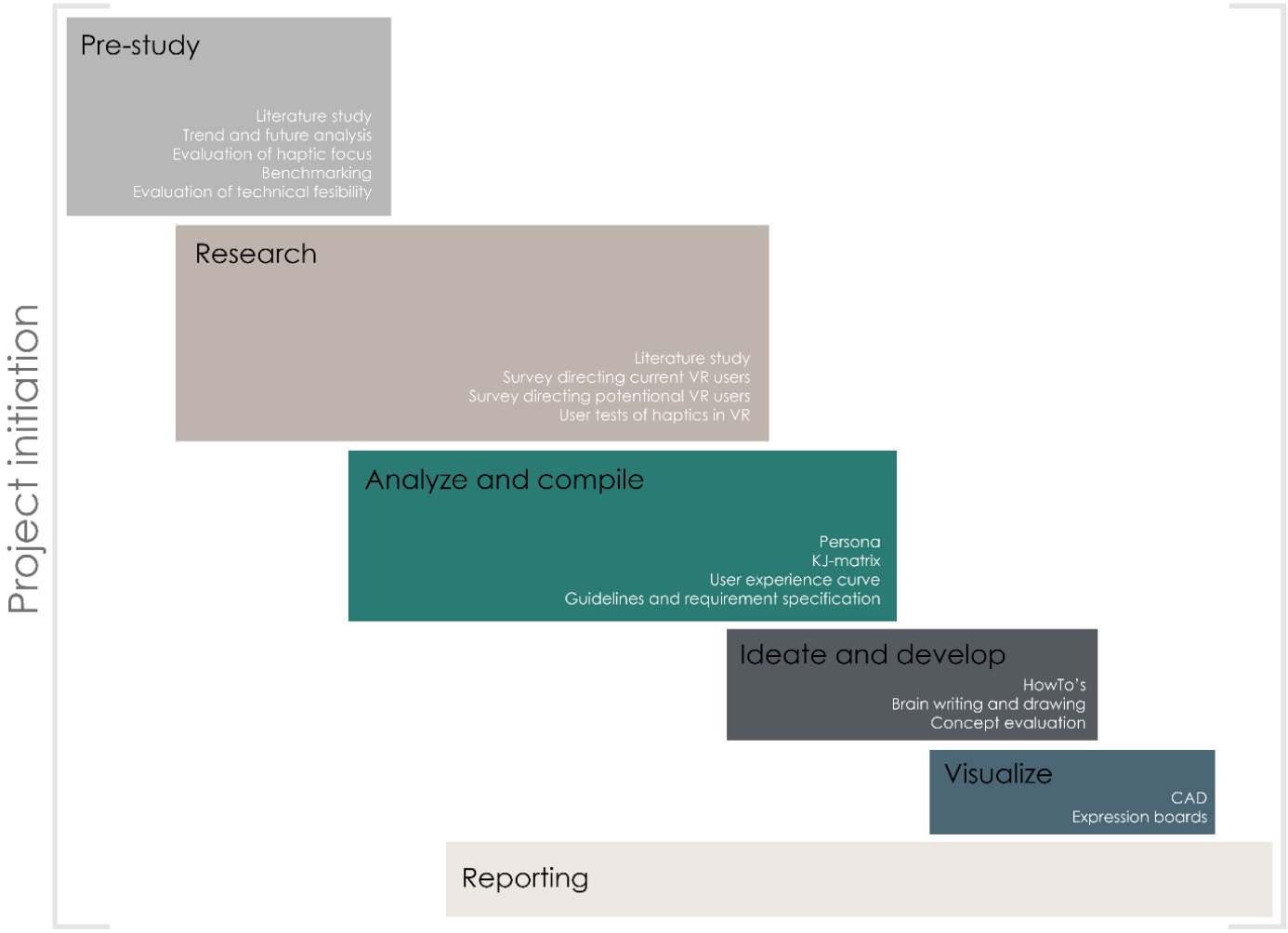


Figure 11 Gantt schedule with project activities distributed over time.

Areas of prioritization and project importance

To meet the task of this project, some investigations are of greater importance and should be prioritized. These are:

1. Study the trends and functionality of VR to understand where its possibilities and challenges lies, as well as how this technology is forecasted to change in the near future. This means that the product concept is not just applicable right now, and also functions to identify a haptic body area to focus upon.
2. Identify what a greater VR experience translates to, via user studies investigate which and how experiences could be suitably enhanced by haptics
3. Compile user experience guidelines and requirements for VR design. Based on the research, these give a foundation to the haptic concept design enhancing current and future VR experiences.
4. A product concept resulting from the previous areas of investigation.

2

Pre-study

2.1 Purpose and Scope

The Pre-study was performed to understand what affects the development of the VR products, as well as what this means in terms of future usage. The pre-study was also intended to shed light into what this means in terms of a haptic VR accessory and from this identify a relevant body area for further haptic investigation. This was important so that the result would be kept relevant in the future and now, but also so that the right haptic experiences was offered for the right purposes. The outcome of this phase was therefore not only a understanding about where VR is going and why, but also what body area is most suitable to give haptics for and what is actually technically feasible to deliver.

2.2 Method

Literature study

The literature study was performed by gathering and analyzing information from various sources about the human sense of somesthesis and haptics. What was furthermore investigated was also what is known about the historic and current development of VR, to offer insights into the current trends and future implications of this technology. Used literature was various articles and reports retrieved over internet, but also a specific trend study regarding VR made by Global Web Index (Buckle and Mander, 2016).

Trend and future analysis

Together with the results of the literature study, a trend analysis was performed through analyzing the change in the Google content of the searched term "Virtual reality". The data items sorted out for analysis was retrieved by using the extended search tools of the Google search function. Analyzed factors was the change in search-hit volumes, and the change in the content in terms of the corresponding pictures and written titles. To establish a change over time, these factors was isolated for each of the years of the time span 2010 to 2016 and the first month of 2017. This time span was picked since the change before this year was incremental and rather similar for the previous years. Additionally, the data was matched against historical events of VR, to observe correlations. The outcome of the trend analysis was understandings of the public interest, expectations and mental image of VR. However, this analysis also gave insights on how certain events has affected the development of VR, and thereby if there are certain stakeholders and interests affecting the VR development. The result on factors affecting the VR development, together with the data of Global Web Index, made a conclusion regarding the public opinion on VR and how the future use of VR is likely to take place.

By investigating the content trends of eight popular scientific articles specifically treating the future use of VR, a summarizing conclusion was drawn about what VR is likely to be used for in the future. To make this analysis of future use areas, a high score list was made from analyzing which and how many times the articles treating the future VR use mentioned certain use areas. The mentioned use areas was additionally balanced against where power and resources are located, which are factors that drives the development. From analyzing articles written by technology experts, whom both are

writing with regards to what is possible to do and what people want to read, general knowledge is retrieved about what people are most interested in using VR for. Knowing this was important since what people want, together with where resources and power are distributed, are the main factors that affects where the development will head.

Evaluation of haptic focus

An evaluation was made to identify what body area of haptic stimuli that should be focused upon for further studies, which was based on the outcome of future use areas of VR. This evaluation was made by balancing different body areas against their approximated usefulness or importance in the most likely future use areas of VR. Lastly, the following criteria was used to lastly determine which body area to focus further development upon:

- Offering a general product over several use cases
- Relevance in the future use scenarios
- Sufficient relevance in the evaluation via the somesthesis sense
- Offering a product that is not in a too big of a focus of development already

The outcome was thereby a body area, which was most useful to offer haptic stimuli for further investigation and product development.

Benchmarking

A benchmarking of available products was performed to create understandings of what types of haptic products that are available, and to understand what is been technically reasonable. The investigated haptic products was chosen due to these having interesting functions of haptic design. This also had to do with that the identified body area proved to have quite few haptic products available. The benchmarking was conducted by analyzing the different products demos and websites, as well as reading various reviews and articles about the products. The latter was also important to get an overview of what types of products actually are out there, and what products are mainly fundraiser concepts. This was especially important since the current nature of VR meant that there is a lot of startup projects in the VR segment, however fewer products are actually available beyond a first prototype. The outcome was therefore what products are out there, and what gap there is for the concept design to fill.

Workshop about technical feasibility

To narrow down the focus of further studies and concept development, a workshop was conducted with scope to evaluate the technical feasibilities. This was done by assessing the opportunities and restrictions of offering haptics in a product accessory to VR for the identified body area. The assessment was made concerning what seemed actually reasonable and possible to do. To be able to ideate conceptually and evaluate imaginary technicality of products that does not exist, the participants of the workshop was set to be five engineering students. The experience and knowledge about VR between the participants varied, which was sought after to access a wide span of knowledge and ideas. The context of the workshop was furthermore set to be less strict

to offer a relaxed atmosphere, to better stimulate ideas and opinions to flow by being a supporting environment.

To perform this ideation and evaluation, the workshop consisted of a procedure of three major parts (Appendix 4). The first part was testing out VR together, to get a common overview of what VR means. This was performed by testing the HTC Vive experience "The Lab", which was chosen due to being representative in its demonstration about what functionality and opportunities VR can offer. In addition to this part, a within-study in terms of an observation was performed, where the participants was instructed to "think out loud" as they tested the VR experience. After all participants had been testing out the VR experience, a brief semi-structured focus group was performed where the participants was asked to comment and evaluate their VR experience. This served to offer understandings about what the participants brings as a bias of VR into the ideation and evaluation parts, but primarily gave general insights about the VR use.

For the second part, the participants were instructed about the task, as well as explained what haptics is and how the human touch works. Furthermore, the participants were presented an order of ideation concerning a categorization of haptic sensations, and was assigned to ideate about what a haptic product accessory to VR could be which offers each of these. The participants were let four minutes of individual brain writing and drawing according the categorization of haptics. Following, each four minute of ideation session was summed up with a short discussion about found ideas and how the participants ideas could lead to new ideas. Lastly, in the third part of the workshop, the participants were instructed to evaluate the ideas from part two in relation to what types of haptic properties seemed most technically realistic to offer in a concept design. This resulted in a set of haptic properties, which was decided to focus on for the rest of the project.

2.3 Result and Analysis

Haptics and the somesthesis sense

What is commonly known as the sense of touch is actually part of a bigger sense, which the expression of touch often is used interchangeably for. This is the sense of somesthesis, and refers to sensory perceptions registered via receptors in the skin, muscles, tendons, joints and inner organs, which means that the somesthesis is different since it is distributed over the whole body, according to El Saddik et. al. The somesthesis is responsible for perceptions as e.g. temperature, strokes, pain and position, more specifically presented, arranged and related to haptics in Figure 12, according to the definition by El Saddik et. al.:

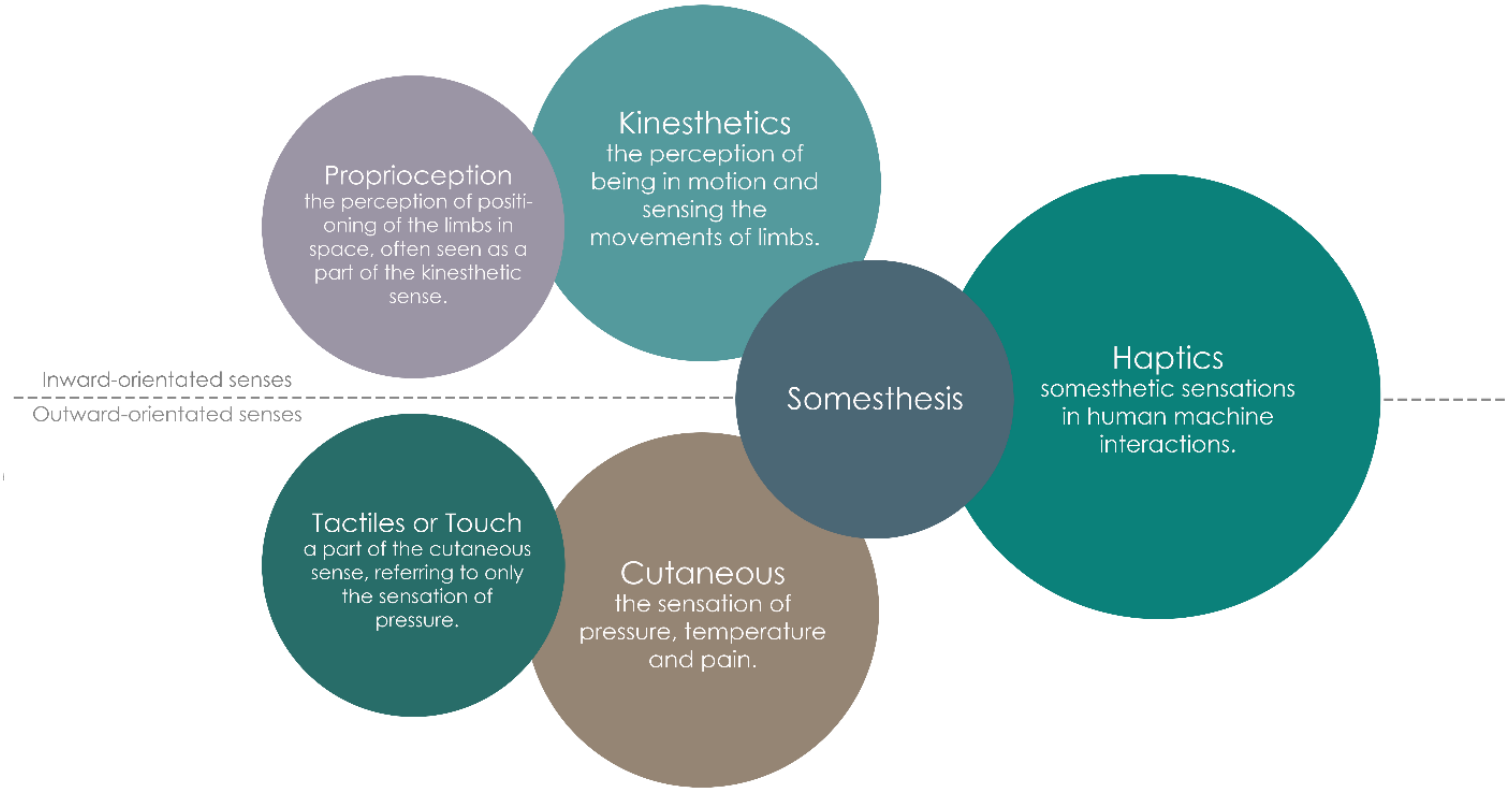


Figure 12 The relation between the properties of the somesthesis sense and haptics.

Since the receptors are spread unevenly over the body, some parts of the body are more sensitive than others to stimuli. The sensitivity of the body areas is described by the "Cortical homunculus", seen in Figure 13 (Penfield et. al.,1937). Accordingly, the most sensitive ones are the hands, genitals and face but also the feet to some extent. As illustrated, offering haptic to these areas will generate more powerful experiences than the other body areas.

Figure 13 The Cortical Homunculus.

When signals from the somesthetic receptors reaches the sensorium part of the brain, sensory experiences are perceived. From these signals, information is given about the state and positioning of the body parts in space (Bjerneroth, 2005). According to El Saddik et. al., combining two or more types of this sense refines the sensory input, leading to refined perceptions of e.g. wetness or vibrations. Some sensory signals also travel through the same nerve path and therefore perceived similarly, as e.g. temperature and pain, according to Bjerneroth. As for pain, a consequence of general unpleasantness and pain is the unconscious activation of the sympathetic nervous system, which except from increased pulse and blood pressure, also leads to movement reflexes to protect the body from whatever is inflicting this. Therefore, protecting oneself from harm is not only a conscious act, but also automatic reaction.

Besides the somesthesis communicating the state of the body, it is also part of the communication between humans, and human and objects (Chillot, 2013). Different human societies have different approaches to touch and when appropriately applied. Chillot adds that even though used for communication, many are not used to touching strangers or even known people. If a touch is appropriate differs between people, but also between cultures. As for objects, the haptic appearance will shape the emotions surrounding it and the situation it is placed in. The touch therefore holds important effects on elicited emotions in communication, but the deep meanings attached implies that it also must be used carefully. Overall, if haptics are appropriate or not has to do with combinations of context, quality, duration, intensity and circumstances.

Since the somesthesis shapes our perception of reality and our presence in it, haptics are important to create the full feeling of presence in VR. But, to understand how the somesthesis supports the human functions, it is easier to approach it as what happens

when this ability is lost. Reported cases of individuals losing all somesthetic perceptions except temperature and pain, is described by Robles-De-La-Torre as extensive problematics with the following:

- Difficulties with walking and standing
- Falling when not being able to see oneself
- Problems with controlling and moving limbs
- Grasping and manipulating objects
- Learning new motor skills
- Managing tasks with cognitive load with fine motor control
- Body communication and evaluating others intentions

However, in VR it is not entirely true that all somesthetic impressions are gone, since feedback is still received from the inward-orientated senses. All outward-orientated impression of the virtual world is however lost, which means the users relation to it. Vision and hearing can be used to cover up for this loss however not fully, which has been seen in cases where humans have lost the somesthesis. For a full and realistic feeling of immersion into a virtual experience, haptic feedback is important, Robles-De-La-Torre stresses. If not providing sufficient haptics feedback in VR, problems could therefore occur with performing normal and top performance tasks, but also in understanding how interactions reflects on the virtual world and the users situational learnings. Consequently, this means that virtual experience training simulators, for e.g. surgeries, cannot be realized if not haptics are integrated. Robles-De-La-Torre points out that providing haptic feedback does not have to be as complex as it appears, since just some reduced info could be enough. The right haptics is more important than enabling all haptics.

Trends and expectations of Virtual Reality

To understand the trends, attitudes, expectations and predictions of where VR is going the history of VR and why it is a hot topic right now is important. VR is not something new, where the first prototype of a manufactured reality might be debated. Some means that the first types was big, realistic paintings or any of out-of-body experience (Robertson and Zelenko, 2014). However, the first VR headset emerged in the 50's, followed by a big boom in the 90's, when an expensive VR headset became available at the same time as movies about VR was launched, e.g. the Matrix or the Lawnmower Man. Due to technological complexity, price and quality, VR has until now not been available for a greater public. This started with the public attention surrounding Oculus in 2012, as previous technical problems had been solved. This lead to a fundraiser of a developers kit released in 2013, culminating by Facebook buying Oculus in 2014. Facebook buying Oculus started the big public hype around VR, leading to the VR race between Oculus and the HTC and Valve cooperation.

A timeline matrix, seen in Figure 14, shows these milestones of the VR development balanced against the change in the Google search hits volume regarding VR, and the content. The line indicates the race of interest and expectations, which follows the historic events. The Google content about VR also depicts a change (further extended in Appendix 1). The content has changed very rapidly from a very high-tech, futuristic

and technology exploring perspective, to a using and evaluating phase. This phase means that the expectations are extremely high on what VR can offer, and that the experiences should hold the according quality. However, this could pose a threat, since the technology just recently got to work, and a lot is still to explore.

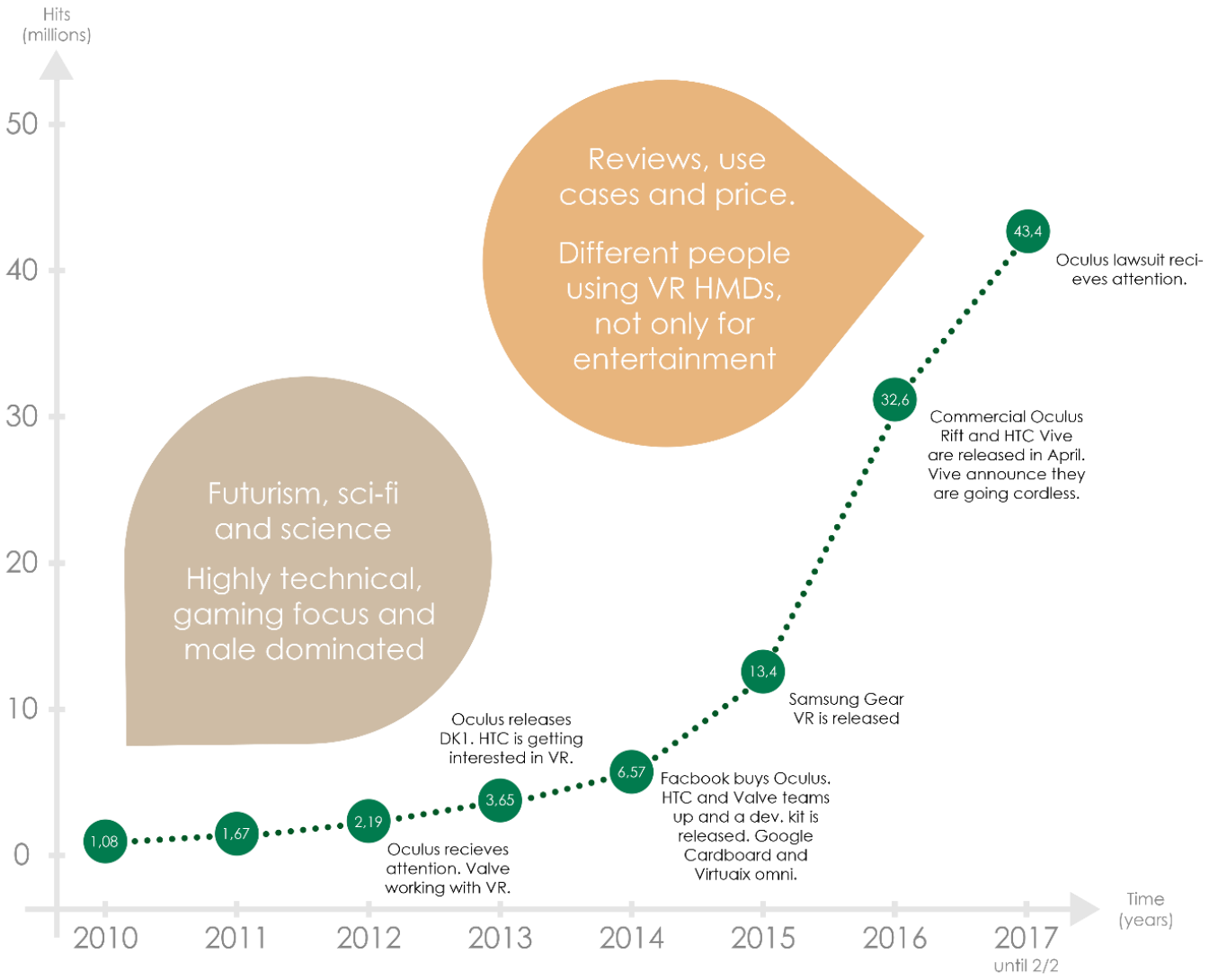


Figure 14 Matrix relating change in search-hit volume, with development milestones and content change.

From analyzing these trends, expectations and development relations, the following conclusions can be drawn regarding what factors which will affect the further development of VR, from a target group perspective.

High expectations

Since attention and hype surrounding VR is the reason why VR turned big, the expectations are enormous on what is to come – but also on the functionality and content of now.

From discovering to evaluating

Related to the high expectations, that there are VR headsets available commercially now means that a new phase is entered. The discussion has shifted from discovering what VR is and how it works, to rating how well it works and if it matches the expectations. This evaluation also means that skepticism and negative approaches are emerging, and questioning if VR will make the expected impact on the future.

Targeting a wider group

Since VR headset recently became available to a larger group of users than developers, it is also just recently a wider target group have been targeted. This can be seen especially in the picture content analysis, which since 2010 has shifted from a very technical focus to pictures of different people using VR. A shift in who the users are is also seen, in terms of gender and the deptiction of these. This does not mean the actual user group is gender equal or a variance in use cases, but it illustrates an ambition.

Futurism and high tech

Due to that it is just recently a wider target group have been tried to be reached out to, VR is still located in the technology zone. This is seen in that portrayed use cases are still very technical or for gaming. In common for the content from all these years is portraying VR as the future while using an sci-fi approach to what this means. This has been proved useful for creating an interest regarding VR, but it could however exclude individuals with lower self-confidence in new technology, which is not useful if a wider target group is trying to be reached.

A trend analysis conducted by Global Web Index, consists of data retrieved globally from all internet users and VR (Buckle and Mander, 2016). Buckle and Mander generally means that four out of ten internet users are expressing a desire of future VR use, but that this interest also increases the younger you are. Furthermore, China has taken an even more optimistic approach to VR, and in general Asia Pacific, Latin America, Middle East and Africa are more interested than Europe and North America. According to Buckle and Mander, the general challenges and the implications on the future of VR, are condensed in Table 3.

Table 3 The challenges and future implications of VR according to Buckle and Mander.

CHALLENGES FACING VR NOW	IMPLICATIONS ON THE FUTURE OF VR
Need for content While investments has been put into developing the hardware, available and engaging content is needed to meet the consumer expectations and furthermore make VR step out of the technology niche.	*Mobile VR* Mobile VR will be where the majority of the first-time users tries out this technology, why the content given here is key to the popularity of VR.
High price The high price eliminates potential users and at the same time exposure is what VR need to become and established.	*Pusher of technology* High-end VR will be the medium for pushing the boundaries of what might be done with VR, why the price of such solutions as Oculus Rift and HTC Vive will continue to be high.
Capacity of the devices Related to the price, the used devices to enable VR experiences will determine the future use. The more immerged experiences, the more powerful devices needed. At the same time, Google Cardboard offers affordable mobile VR, while Google Daydream is pushing the boundaries of what can be done with mobile VR.	*Gaming and marketing* VR will continue to play a role in the gaming industry, where product innovation is key. Due to the user engaging abilities of VR, opportunities are opening up for marketing and PR in this medium.
	Cynics There are people expressing worries about this technology, and mainly the anti-social aspect to it.

Future use areas of Virtual Reality

Combining the data presented until this point, and the data from Buckle and Mander, there are three likely scenarios of future VR use. The likelihood also has to do with the location of estimated power and resources, but since the public attention is big and powerful companies are investing in VR, it seems as whatever the scenario the VR technology is here to stay. Following, the scenarios are depicted and presented in relation to predicted likelihood, though it is possible for these to co-exist.

1. *High-end VR for professional use*
   The possibilities of lowering the costs or making new functions possible by using VR for businesses, will make high-end VR an invaluable tool in e.g. manufacturing industries, education, medicine, military, tourism, etc. However, high-end VR will not be adopted by a larger group of private users than those currently reached if not additional value is offered.

2. *Mobile VR for private use*
   Due to the lowered price, availability, increased smartphone capacity and pushing what might be done, mobile VR is the medium where the large majority of the potential private users are located, however the extent also relies on what value is offered.

3. *High-end VR for private use requires an additional factor*
   For high-end VR to be adopted among a larger group of users, an additional factor appears which motivates private users to buy high-end VR. Consequently, this leads to lowering the costs of high-end VR, increasing the exposure and the availability. Such factors could e.g. be Facebook delivering a compelling social experience, the gaming industry successfully makes use of VR to attract a great audience, or climate changes restraint humans natural patterns of living which opens up a space for VR to play a role.

By analyzing the future use areas of VR, a hint is given of what areas is the most likely to take place. Table 4, based on the categorization and compilation of the times the corresponding areas of use was mentioned (Appendix 2), presents the current use areas, those being of future interest and those where power and resources are located except from being of interest.

Table 4 The use areas of VR, current, potential of interest and localization of power and resources.

CURRENT USE AREAS	POTENTIONAL USE AREAS OF INTEREST	USE AREAS OF POWER AND RESOURCES LOCALIZATION
Entertainment, mainly games and movies	Healthcare	Social functions
Business, marketing and organizations	Education	Gaming industry
Showcasing technology and functionality	Consumer activities	Business, marketing and organizations
	Journalism	Military
	Room design and real estate previews	Science and all societal institutions and functions
	Meditation	Climate changes related use areas
	Scientific data visualization	

The use areas of entertainment, business, healthcare and education are areas where the VR technology is most interesting to be useful, though entertainment dominates the interest above all the other categories. Besides these, shopping, journalism, room design and real estate previews, meditation and scientific data visualization sticks out as connected with areas where VR could be useful, but not of highest interest. The resources of investment and power are located within especially social functions, which is not that common mentioned. Since Facebook is one of the most powerful drivers in the VR development, this use area is still highly likely to occur. Gaming is also a use area of resources, since it is said by Buckle and Mander to be an industry characterized by high technology products and product innovation. In addition, gaming and entertainment are primarily the use areas where VR has been introduced until this point, why it will continue to be relevant. The business use area, science, healthcare, education and other societal functions are also use areas where resources and power are located, especially in the case of military. Lastly, spending a lot of time in VR due to climate changes, e.g. integrating major parts of human lives into VR, might be even more likely depending on local and global climate disruptions.

For the likely future use areas, some VR platforms are more relevant than others. The most likely use areas are presented in relation to relevant VR platform of use, seen in Table 5. If the use area has a likelihood of occurring in private use mobile VR will be used, e.g. movies and marketing. However, if it is likely to be increased demands on quality, high-end VR is more likely to be used, e.g. for product prototyping or healthcare treatments.

Table 5 Future use areas of VR versus likely used platform.

USE AREA	LIKELY FUTURE VR PLATFORM OF USE AREA
Entertainment	Mobile VR or high-end VR
Business, marketing and organizations	Mobile VR or high-end VR
Healthcare	High-end VR
Education	High-end VR
Social functions	Mobile VR or high-end VR
Science and societal institutions	High-end VR
Military	High-end VR
Climate change uses	High-end VR

Considerations regarding haptics

Depending on how important the immersion of the user will be the importance of adding haptic stimuli increases. Translating the future use areas into potential use and relevance of haptics, and arranging according to body area sensitivity, the following result emerges (extended version found in Appendix 3).

1. *Hands haptics*
   Gaming, healthcare, education, military, climate change uses architecture and civil engineering, workspace and productivity, consumer activities, science

2. *Head and neck haptics*
   Gaming, healthcare, military, climate change uses, science

3. *Feet haptics*
   All entertaining experiences, education, military, climate change uses, architecture and civil engineering, social, well-ness, consumer activities, science, therapeutic, rehab

4. *Torso and arms haptics*
   Gaming, work-out, shopping, healthcare, military, climate change uses, science

5. *Legs haptics*
   Gaming, work-out, shopping, healthcare, military, climate change uses, science

From this estimation of future use areas of VR haptics, a conclusion can be drawn that hands and feet will be most frequently having use of haptics rather than torso, arms, legs, head and neck. The hands, and its haptics, currently are of big focus and will continue to be important with future use areas. However, the touch sensitivity in the hands, in combination with that the hands are playing a central role in the use areas where power and resources lies, means that it is more likely that hand haptics will be specially developed for these use cases, rather than relying on a general solution. An example is hand haptics for surgery training, which probably will differ in its execution and design from hand haptics for gaming.

Table 6 Considerations of hand haptics versus feet haptics.

HANDS	FEET
Consciously important and sensitive	Unconsciously important and less sensitive
In focus	General over several use areas
Moving towards no controllers	Not of primary focus right now
Interests and resources drives special development of controllers	Always in touch

Stimulating the feet with haptics differs from the hand haptics since the feet are not that sensitive to haptics. However, the feet holds the unique property of constantly being in contact with the ground, offering information about the surrounding world. But as hand haptics, feet haptics are relevant in many of the use areas where power and resources are located, in addition to be relevant in other use areas. Since the feet are not that sensitive as other body areas, while being relevant over many use areas, a general feet haptic solution could be useful. The generality of such a solution might further mean a decrease in cost due to it being applicable in so many use areas, increasing its relevance

if private users would increasingly use high-end VR. Consequently, feet haptics for VR is therefore an interesting area of further investigation.

Benchmarking

There are many products accessories to VR, however few available commercially. This is especially the case when referring to input accessories to high-end VR, as there seem to be even more products than headsets. Most common are the hand held devices joining the most common headsets, e.g. the HTC Vive controllers, the Google Daydream controller, the Oculus Rift controller (as previously seen in Picture 5 and 3) and Oculus Touch (Figure15). In addition, there are various wearables offering tracking and input to the experience. Trends moves toward the kind of input techniques where gestures are tracked, rather than making use of an actual controller. Many hand controller and wearable offers haptic feedback in addition to being an input device, e.g. Reactive grip. There are also wearables only offering haptic feedback, as e.g. Teslasuit, KOR-FX haptic vest and Woojer (seen in Figure 15, and Teslasuit seen previously in Figure 8).

Figure 15 Oculus touch controller (top left), Reactive grip controller(top right), Woojer vest (bottom left) and KOR-FX haptic vest (bottom right).

When focusing on feet accessories there are fewer products available. There are some product accessories, which realize body movements and fixates the user in the real world environment while moving in VR, e.g. treadmill products as Virtuix Omni, Cyberith Omni (previously seen in Figure 7). There are also purpose specialized products of this kind, e.g. the bike VirZoom or the flying simulator Birdly (Figure 16), the latter also offering haptic feedback in terms of wind streams. There are product variants also offering the sense of motion, in terms of moving inaccurately as to a real world interaction, e.g. the motion board 3DRudder (Figure 16) and the chair Roto VR (seen previously in Figure 7).

Figure 16 VirZoom bike, Birdly flying simulator and 3DRudder.

When specifically focusing on feet haptics the products are even fewer. There is primary one product example that offers haptic feedback, which is the Taclim boots (seen previously in Figure 8). Except these boots, the treadmill products are also offering some haptic feet feedback, as they are providing the sense of motion and limb position in space. Products tracking the feet into VR also provides to this perception, even though visually seeing your feet is not haptics but rather completes the circle. Examples of such tracking accessories are e.g. Vive Trackers and Virtuix Omni Tracking Pods (Figure 17).

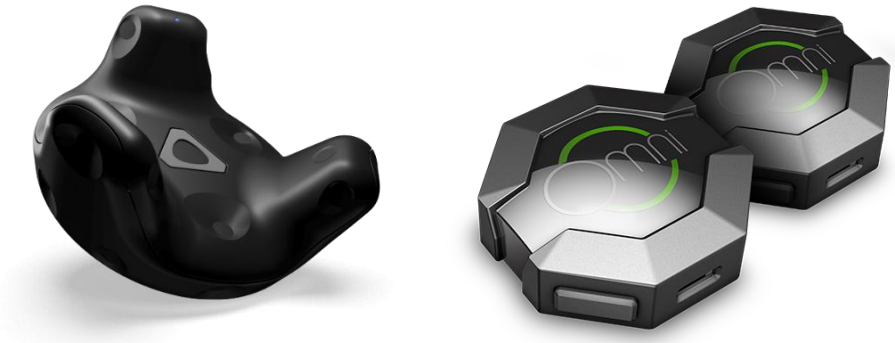


Figure 17 Vive Trackers (left) and Virtuix Omni Tracking Pods (right).

The majority of the VR products and accessories holds a relatively expensive price in relation to offered functionality and content. The price is not very much lower in relation to the main high-end VR equipment, holding prices from $500-1000. The high price is a consequence of the newness of these technologies and that they are expensive to manufacture in relation to how many that are sold. As all the product accessories are very new, few are sold for commercial purposes, why exact prices are hard to find. Since none of these products can be bought in physical stores, the price also heavily relies on international shipping fees. For the Virtuix Omni products some prices are however published, where the Virtuix Omni Tracking Pods holds the prize of $149 and Virtuix Omni Shoes $99. Since these are only accessories to the main accessory, this indicates the situation of the price range of these products.

There seem to be a hole to fill in the VR market for a haptic feet feedback product that actually exists, is reasonable to manufacture and is actually available to purchase. This availability is also characterized by holding a lower price, not only to other VR accessories but also in relation to the VR HMDs since these are the actual VR products. Availability is also defined by being a stand-alone accessory that does not need other accessories except the VR headset.

While many accessories are still in their prototyping phase or developed for gamers, a consequence is that they either look like gaming products or at least very technical. Nevertheless, all of these products hold a dark, technical and hard design language, which often communicate sci-fi movies and games rather than other purposes. This might appeal to the current users, but means that if a larger group of users is sought, a change in design language is beneficial.

Consequently, the following properties are those of an interesting gap to fill for the upcoming concept development:

- Actually being possible to manufacture for a greater use adoption
- Providing and communicating an easy used immersion beyond being a gimmick
- Lower price in relation to high-end VR HMDs and offering more functionality per invested currency unit than other VR product accessories
- Not dependent on additional product accessories
- Sustainable

Technical feasibility

The workshop about technical feasibility of a feet haptic VR accessory gave a foundation for decision of what seemed technically reasonable to do. Starting with the result from the ideation and evaluation (found in Appendix 5), many of the haptic properties were perceived as difficult by the participants to find technically easily product designs for – especially with the approach of being general. This was mainly due to the factor of change, meaning changing the haptic feedback between feet experiences within a specific VR experience, but also changing between various VR experiences. The ideas presented and deemed as most realistic to perform were commonly making some kind of boot or a ground foundation, which would combine haptics with illusion or other kinds

of feedback. In terms of the haptic properties, passive haptic impressions were perceived as most reasonable and lowest hanging fruit. Of these, the pressure-related sensations of texture, hardness, size and shape together with some temperature were deemed as most reasonable to offer via a haptic product design (as seen in Table 7). When giving these properties, the participants agreed upon that a naturally elicited perception of proprioception was likely to emerge. It was also discussed whether offering exactly the right type of haptic feedback was relevant, and if giving haptic feedback together with illusions, tracking of the body and auditory feedback would mean a matching or overlapping experience, which could be perceived as just as accurate as or even better than realistic haptics. Some also added that most of our day we are using shoes, further questioning whether being relevant or even realistic to feel everything anyway.

What was deemed difficult was haptic inputs not being able to perform by passive haptics. This due to that they were more advanced, which also would make the simulation of these advanced. Consequently, these were direct modifications of body movements, motion and position in space in-between the real world and VR (seen in Table 7). If however simulating this, it was suggested that some sort of technique would be needed that directly influenced the brain, or was some sort of air tunnel allowing the user to move freely. However, some also added whether there would be sufficient use cases for these uses motivating such a product development.

Table 7 Evaluation of technical feasibility in haptic properties.

REASONABLE	ADVANCED
Direct modifications on the perception of	
Texture Hardness Temperature Size and shape	Movements and motion of user in real world versus VR Position of the body in space

Introducing evaluation of a general experience

The insights from the within test offered introducing and general insights regarding how VR is perceived by unexperienced users. What was sticking out was the "Wow-factor" that everyone perceived. However, this did not arise immediately as there was a lot of hassles for the participants when entering the experience, in terms of putting on the HMD and understand the controller's functionality. One participant also explicitly expressed being nervous before trying, a consequence of being first time user. When into the experience, this participant expressed feeling calmed when accompanied by a robotic pet dog of "The Lab", furthermore acting as a companion. The participant stated that this dog changed the perception to less scary and more trusting when added to the experience.

"IT WAS VERY NICE OF THEM TO ADD ONE OF THESE [REFERRING WITH AWE TO THE DOG], BECAUSE NOW EVERYTHING FEELS VERY WELL-INTENDED."

During the VR use, it was observed that it was difficult for the users to stay within the guardian grid, understand ones relations to this and remember its existence. Consequently this lead to the participants hitting walls and other things outside this grid, especially when having the attention at other things. In the same manner, it was difficult to keep track of the HMD cord, where the participants tripped over this or had to be reminded of this to not trip. When one of the participants tripped into a table placed outside the virtual room of the VR experience, the participant reacted by shouting out with fright, followed by being upset of not being warned for this. Another participant later said that they had to learn to control their impulses, in terms of not running, moving quick, doing sudden moves or trying to lean on virtual objects.

"I HAVE TO HOLD BACK CERTAIN IMPULSES, THAT YOU CAN LEAN ON A TABLE OR MOVE QUICKLY. BUT RIGHT NOW I WAS AWARE OF THIS."

"ONE HAS TO BE ABLE TO DO MORE THINGS THAT YOU CAN DO IN THE REAL WORLD, BUT MAYBE YOU DO NOT NEED TO BE ABLE TO DO ALL THE THINGS YOU CAN DO IN THE REAL WORLD."

The results imply that there are problems with VR shutting out the real world, but also that the available degree immersion is already sufficient for users to react as they would to a real experience. Therefore, users react similarly as they would in the real world to a similar experience, while there are still restraints in the current VR technique in what types of physical reactions that might be tolerated. Furthermore, these restraints are insufficiently communicated to the users, which leads to this types of accidents of e.g. hitting things, trying to lean on virtual objects or tripping on the cord. One participant also added that one has to be able to do more things in VR that you can do in the real world, as e.g. running, however speculating that not all things has to be enabled. A conclusion to this is that

when creating VR experiences it is more relevant to allow the right types of real life reactions and interactions, rather than offering all of these.

When exiting the experience, many of the participants reacted with a heavy breath when taking of the HMD, followed by a "wow" or "oh". Some participants were also observed to move their eyes in a manner to adjust to the new visual input. Many also added that the experience was much more realistic than they ever believed. Some joked about the real world turning much more boring now due to the fantastic simulations possible in VR. Since the participants perceived the experience as realistic as they did, it also manifested in other reactions. This was seen by one participant finding passing through objects in VR as very odd, which afterwards was highly discussed by this participant. This indicates that the realistic immersion of VR also means that users perceive that doing things one cannot do in real life experiences is wrong. Therefore the users does not want to do it in VR – eve though they seem to be able to learn that they can do this. This raises interesting questions about what is ethically right to do in VR, since unconscious learning in VR could reflect on interactions and reactions in real life, e.g. unaffected approaching objects and further bumping into them.

"IT FELT WRONG TO BE PASSING THROUGH THAT THING, YOU KNOW?"

"WAIT, I SHOULD BE FEELING SOMETHING NOW WITH MY FEET!"

Since the participants were informed about the workshop treating haptic feet experiences, some initially tried to reflect on this when in VR. It was initially expressed by some participants that they should be feeling something in their feet for some explicit experiences. One participant reacted with comical panic to that the feet were missing, which was perceived weird. This indicates said in the ideation workshop, which not all haptic feet impressions need to be given. However, it was also observed that as time passed in the experience, or the experience itself intensified, they forgot reflecting on this and rather focused on all the other impressions deemed more important.

"WHERE ARE MY FEET!? NO!"

2.4 Discussion

From this Pre-study, some conclusions were drawn regarding the trends and forecast of the future of VR. What stands out is the future of high-end VR, also being the medium this project focuses upon, which was found to be less likely to be of common use among private users. Mainly, this was due to the availability and high price of these, if not an additional factor can play in to motivate such an expensive purchase. For private use, mobile VR was instead found to be more likely, even though also having some challenges to address in order to reach a greater public. However, high-end VR is likely to be found invaluable within the professional sector, to which most of the VR showroom and event activities of DigitasLBi belongs. Until further event takes place, this stresses that developing high-end VR experiences to be used at home is something that should not be focused upon. In this project, further research and development of haptics should not focus on being a product used at home, but instead for public use in e.g. showrooms or events. Consequently, this means that the haptic VR accessory will be less sensitive to price and regard experiences of shorter time duration, due to them being for professional use rather than private.

As a part of the analysis of which haptic body area to focus further research upon, the feet was found relevant, due to that VR feet haptics could offer a solution that is general over several experiences. This due to the qualities of the relevant use areas, and the feet being insensitive. However, the insensitivity in itself could the other way around mean irrelevance. Why offer haptic stimuli to a body area that is less sensitive than other, which further could mean less importance in terms of gathering information? As previously noted, the feet are always in contact with the ground, which means that important information about the surrounding world is retrieved via the feet. Similarly, being less sensitive is not the same as unimportant, but rather a measure of conscious thinking, which will be discussed later on. A similar argumentation holds to why haptics stimuli is relevant for this body area if it has not been missed before. Not developing products due to that an explicit desire of this not expressed by the current users is never a full motivation to not developing new products. This is especially the case when previous research has strongly shown that haptics increases the immersion in VR, furthermore enhancing the experience. For most experiences, current ones and those of the future, this immersion is the essential functionality of the experiences. Consequently, offering feet haptics cannot be dismissed as irrelevant due to the feet being less sensitive or that users have never expressed a need of this before.

Regarding the evaluation of future VR use areas of user interest, it is relevant to question the execution of this method, since it was based on what was written over various articles regarding this subject. It is commonly considered that users cannot know what they want to have, if not having an actual product use case at hand which is to be updated to a better version. This means that asking what the users want to use VR for in the future is something that is generally difficult for most to hold an opinion upon, and could lead to abstract guesses. Therefore, the method was based on analyzing articles in this subject which was written by popular scientific journalists. This was due to that it is reasonable to

assume that the writers of these have not grasped the content entirely out of the blue, but that the articles are based upon some research, while being considered to hold the perspective of the interests of the common users in mind. Consequently, their discussions of future use areas should be viewed upon as guiding, to narrow down the wide possibilities at hand. At the same time, these should be approached as changeable, due to being dependent on what types of content that will appear in the following years, which steers the public opinion.

A similar argumentation holds for the input data of the Google content trend analysis. The Google content trend analysis is naturally affected by the factor of Googles own agenda when using their search tools, which is important to consider. Except avoiding sponsored data and making use of incognito searches, inbuilt unknown agendas within the Google search tool was considered too difficult to avoid, in relation to how much time would be needed to bypass these and that the elicited information seemed reasonable. Also, if there would be biases in the search measures, these are probably more specific than interfering with an overall historic search. Therefore, this was not considered to be worth further hassles, in consideration to that reasonable information was able to be elicited anyway.

Except of finding a body area to focus further haptic research upon, an important part of the Pre-study was to investigate the technical feasibility via the workshop. Limiting the development early on could restrict the incoming concept development, however it was necessary to narrow down the focus for further research. But evaluating the technical feasibility of the ideas in this workshop could by itself be considered as difficult, since it is tricky to evaluate technical functionalities of concept ideas that does not exist. Additionally, the subject of VR and the somesthesis sense requires knowledge to base a further ideation upon, why the area itself could be considered as difficult. To ease these difficulties, measures were taken via that the sample of participants were chosen to be engineering students with experience of holistic working methods. Sufficient, yet unrestricting, information was also given to offer understandings about how VR and the somesthesis sense works. This means that the evaluation of technical unfeasibility does not strictly induce that these haptic properties are forever impossible, however too advanced and unrealistic within the set time frame of this project.

2.3 Conclusion

This chapter treated what the trends and future implications of VR are, and how this affects the development of a technically feasible haptic product that is useful over several use areas. The trend analysis proved that there are huge expectations regarding VR, but that the subject has altered from an exploring phase to an evaluating. What is critical for a wide breakthrough is meaningful content, as well as price and capacity, which determines the availability. This means that the mobile VR devices, currently being the gate for first time users, will continue to be the VR medium where most private users gets in contact with VR. As high-end VR devices pushes the development of what might be done, these will continue to hold a high price. It is therefore not very likely that high-end VR products will be used by a wider audience of private users - if not an additional factor plays in to motivate them. It is more likely that high-end VR will be used as a professional and business tool, as in the case of DigitasLBi, since VR holds invaluable prototyping and visualization possibilities for such stakeholders. In relation to this, early indications of problems when using high-end VR treated technical hassles of the HMD, being scared when first trying VR and mapping between real and virtual world, leading to e.g. running into things or tripping on the cord.

Haptics refers to when sensations as e.g. pressures and temperatures are provided in human machine interactions, commonly referred to as touch. However, the touch is actually a part of a bigger sense called somesthesis, referring to perceiving the sensations of pressures, temperatures, pain, motion, speed and limb position in space. Since the previous development has mainly focused upon developing the functionality of visual and audial immersions into VR, less focus has been put on haptics. In the trend and future analysis, it was also found that the further focus should be put on developing a feet haptic VR accessory to enhance VR experiences. This was due to that the feet are not as sensitive as other body areas, but they are not unimportant as they are in constant contact with the surroundings. A feet haptic accessory could therefore offer a general product that might be used over several areas of use. As there exists very few haptic products of this kind, a gap is available to fill in terms of a product that is not a gimmick, has a sustainable perspective, holds a lower price in relation to HMDs and targets a wider group of users. When regarding what haptic properties to design such a product for, the pressure-related sensations of texture, hardness, size and shape, as well as temperature, was found to hold the greatest technical feasibility for further concept development.

3

Experience and sensory design

3.1 Purpose and Scope

To investigate user experience design and haptic design in VR, it was crucial to investigate what is already known. Insights of what creates the experiences in VR were also important even if it concerned mostly visuals, due to that the senses interact in how the experience is evaluated. General insights were connected with relevant studies of the perception of haptics to gather insights about how to apply this in sensorial VR design. Consequently, the outcomes were guidelines, models and insights about what had been learnt until this point about VR and the perception of haptics, in order to create better and enhanced VR experiences.

3.2 Method

Literature study

The literature study was performed by reading and compiling information from various sources about what is known regarding experience design in VR and haptics. Furthermore, already published guidelines for user experience design was studied, as well as articles regarding ethics and code of conduct for VR experience design. Altogether, these gave a ground for further research. The sources was often online articles, but commonly reports from previous research studies in these fields.

3.3 Result and Analysis

Models, theories and guidelines of experience design in Virtual reality

Needs and evaluation of content

As a consequence of that anxiety was observed within the VR community regarding the need for quality in VR and how to achieve this to reach more users, Maslow's hierarchy of needs for the development of VR experiences (seen in Figure 18) was established (Cronin, 2015).

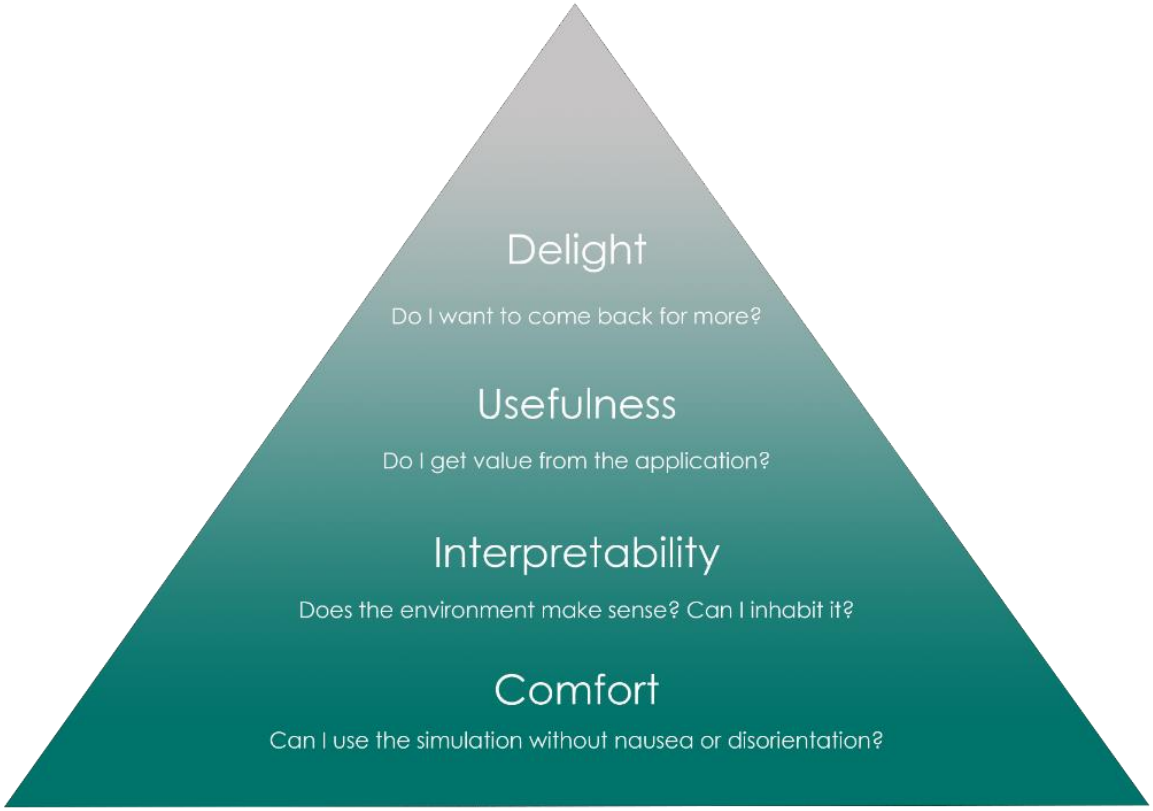


Figure 18 Maslow's hierarchy of needs for the development of VR experiences.

This pyramid is spanning from basic human needs in the bottom, to the unique selling point of a product (USP) at the top. Consequently, for this pyramid there are the four steps that one should consider when creating any VR experience, starting from the bottom:

Comfort

This basic step regards the possibility to actually use the experience, which refers to unconscious expectations held on the reality we are put in, as well as how it responds to our interaction with it. This means things like the rendering being accurate according to the movements, and that this rendering does not make us nauseous. Consequently, that the environment is inhabitable for the human brain and its perception of sensory input.

Interpretability

This second basic step regards that the virtual experience has to make sense, which also is an unconscious expectation. This means that what we see is not overwhelming and follows a consistent logic. Even though the experiences themselves might be unrealistic, they must follow the real life quantitative and metaphorical rules.

Usefulness

Leaving the basic steps behind, usefulness simply means that the experiences offer some value and functionality for the user. Consequently, this step means the actual experience and interaction of the VR experience, and that it provides something than just being a virtual experience.

Delight

Being the top of the pyramid, this means e.g. USPs, artistry and the users wanting to come back for more. This differs from the previous step of providing *a* functionality, while this rather means providing *the* functionality that users would want to use.

The most valuable product experience passes through all of these four steps. Though it is added that the steps of Comfort and Interpretability always needs to be fulfilled, which means that presence is created. Comparing this to where most VR experiences are currently situated, the means to solve the step of Comfort has just recently been realized through the progress of development. Simultaneously the step of Interpretability is starting to be fulfilled, however over all experiences there are still problems with e.g. nausea. The steps of Usefulness and Delight has therefore only been entered by a few experiences and means where common and specific insights, as well as functionalities, are in progress of being discovered.

The emotions elicited in an experience is of importance, as emotions generally affects the memory and learning, and consequently the performance (Christianson, 1992). On the other hand, how an experience is perceived emotionally provides to the perception of product properties, e.g. quality, which is generally described by "The appraisal theory" (Desmet, 2002). This theory describes the relation between the users concerns and the product (Figure 19), which for this case refers to the VR experience. The concerns of the users refers to both universal kinds, as described in Maslow's hierarchy, but also to culture and context dependent ones. These build the measures of product appraisal, being the user's goals, standards and attitudes, which balanced into what kind of product emotion that is elicited. Consequently, this model highlights the need of knowing the goals, standards and attitudes of the users of VR experiences, as these measures will affect how the experience in evaluated.

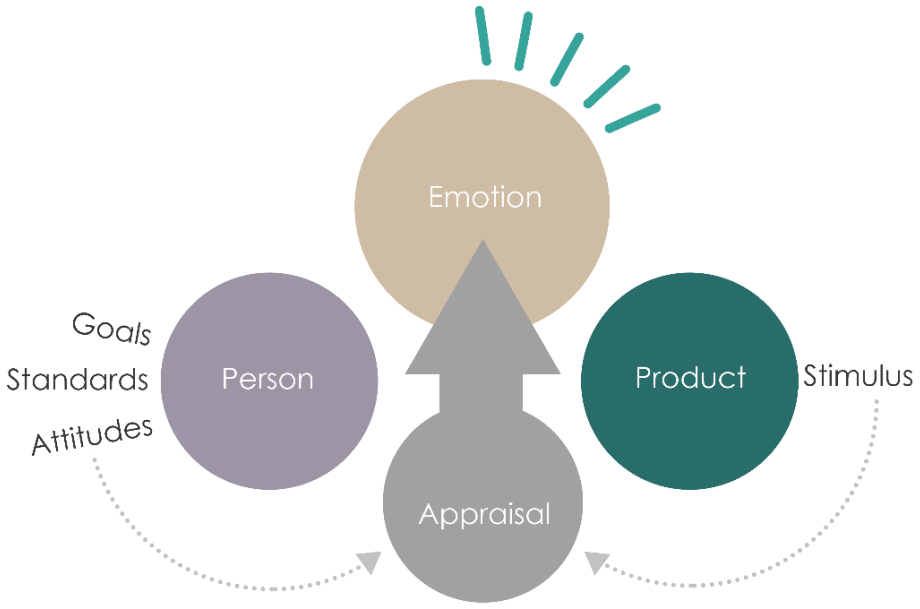


Figure 19 The appraisal theory.

Presence and perception

To understand what kind of presence that is created when making a VR experience, and how it differs from the presence previous digital media have been able to create, the framework "The elemental theory of presence" was created (Bye, 2017). It consists of four pieces, and when each of these are fulfilled a perception of a full immersion and presence is created (Figure 20). The four pieces are here described:

Embodied presence

The user accepts that the body is situated in this world, through the senses confirming this presence. This is what makes VR unique from any previous digital medium.

Emotional presence

The presence of emotional engagement, where what is experienced triggers emotions from the user.

Social and mental presence

That the world interacts with the user and furthermore responds socially and mentally to the user. The user perceives a presence via social and mental interactions with the world, which confirms to the user that these affects other factors or avatars in this world.

Active presence

That the user can express its agencies, and via performing activities in this world, these agencies can be achieved. This consequently means that one actively might do things, which provides to the perception of being present since it confirms that the user is actually there.

This theory is an extended version of what is called "The theory of presence", which was derived by investigating why users of VR experiences tend to respond in a realistic manner (Slater, 2009). This theory explains that the illusion of perceiving presence can be broken down into the two illusions of Place and Plausibility (Figure 20). Place illusion refers to the perception of being there, while Plausibility refers to perceiving the depicted scenario as actually happening. Consequently, when both these are fulfilled the user will react as they would in the real world, even though the user knows that this is not real.

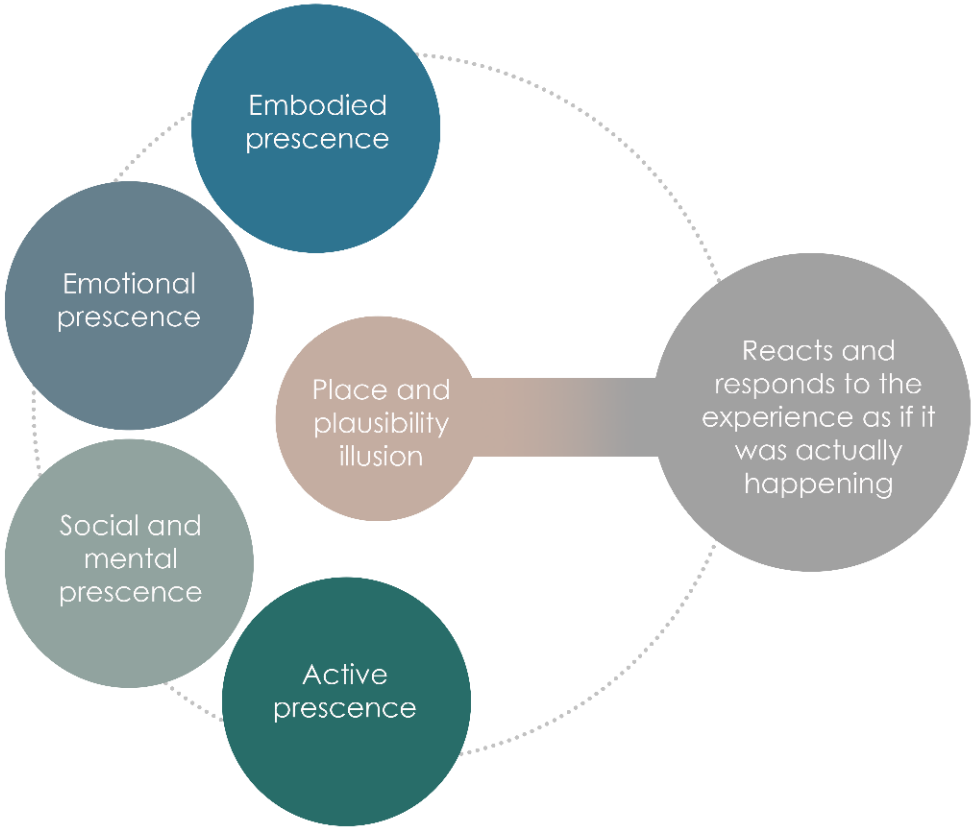


Figure 20 The elemental theory of presence (left), incorporated with The theory of presence (middle-right).

This theory relates to the experiment commonly known as the "rubber hand illusion" (Botvinick and Cohen, 1998). It was found that when an artificial body part was viewed being stroked at the same time as the real body part also was being stroked, the artificial body part was be accepted as being the real one. This means that no matter that the users know that it is not happening, they will not only react to the VR experience as if it was real, but they will simultaneously also perceive happenings to their virtual bodies to be real when feedback of this is given.

Related to this, five insights regarding perception when perceiving presence in a VR experience has been found (Newton, 2016). They were derived from low-fidelity experiments with the approach of storytelling in VR, furthermore quoted accordingly.

1. "Reality is constructed. Once the audience pokes a hole in reality, they have already fallen through it."
2. "Having a body means being somebody. There is no such thing as a neutral observer."
3. "Looking is doing. For better or worse, the audience directs their own gaze."
4. "360° is less than 180°. The more there is to see, the less the audience remembers."
5. "360° is more than full circle. The more complete the environment, the more it resonates."

These insights align with the common saying that reality is a construction of our senses (Hoffman, 2016), and when something feels odd in this it will be discovered and therefore affect the perception of presence. The findings by Newton also relate to "The elemental theory of presence", "The theory of presence" and the "rubber hand illusion", confirming that perceiving having a body means being someone in VR, and thereby the users personality will affect what is experienced. Regarding perception, it brings insights into how much data is put into the experience, in relation to how much is seen in all directions. Thereby, just to be in VR might itself be an activity. This indicates that here is a difference between VR and reality, while previous theories has often focused on that users react similar to VR as reality – however this might not always be the case.

About human perception, it has been stated that everything going on in an environment must not be known or alerted, as long has what is seen right now is locally consistent (Hodgson, 2014). This has to do with how the human spatial memory works, which makes use of all the given information to understand the current environment – no matter if the global environment is actually impossible, physically and mentally. Hodgson also says that at the same time we cannot consciously know everything that is going on. This is due to that the brain unconsciously sorts things out, where only a limited amount of this information will turn conscious. Additionally, there is the phenomena of "change blindness", where studies have found that when focusing on a specific task there can be big changes to the viewed environment without the user noticing. This is also true to real life experiences, and is due to there being such a big focus on the task that this input is sorted out, Hodgson describes. It is said that humans approximately remembers where objects was placed, but not the exact placement. Similarly, Hodgson says that it has been observed that humans underestimate distances in virtual spaces, why game avatars moves in a lot quicker pace than what is normal for a human. Overall, there might occur big inconsistencies in the experience the user is put into, but if these are not in focus of the user they do not matter anyway.

Specific guidelines for Virtual reality design

Basic understandings about how the presence and perception offered by our senses works, and what quality content in VR means, offers general explanations to why the users acts as they do. However, concrete tips and tricks in visual and audial VR design has also been developed, as here presented (Google Cardboard team, 2015):

Foundation

1. "Using a reticle"
   Make use of visual aid the user to know when something is in the center of view.

2. "UI depth and eye strain"
   In VR the legibility is not only determined by font size, contrast and space, but also depth. Too close is within 0.5 meters, which will mean eye strain, while too far is outside 1 meter.

3. "Using constant velocity"
   Use constant and smooth velocity when moving in VR, otherwise there is a risk of motion sickness and discomfort.

4. "Keeping the user grounded"
   To help the user understand what is happening, e.g. of the user is moving or the surrounding objects are moving, reference points to these should be used in the design to help the user understand this.

5. "Maintaining head tracking"
   Regardless of what is experienced, at least one element must maintain head tracking, which has to be smooth and using low-latency.

Immersion

6. "Guiding with light"
   User's attention is drawn to the brightest part in a scene, why a subtle light cue can be used for this.

7. "Leveraging scale"
   Scaling the user relatively the world might be used to affect how the user perceives themselves in this world, and furthermore how this world is perceived.

8. "Spatial audio"
   Move the sound of the scene as the user's field of view turns in the space, as this provides to the immersed perception.

9. "Gaze cues"
   Passive interactions can be used in VR, as the designer always know where the user is looking and thereby can make things happen just by looking at them.

10. "Make it beautiful"
    The illusion will be better if the experience looks better.

These guidelines are however created for three DOF, but they are still generally similar for six DOF experiences, especially when coming to the guidelines of immersion. These also include cues for sensorial design and when several senses interact, as exemplified by the case of moving the sounds as the user moves the head. However, the guideline of making the experience beautiful to make the illusion better is only partly true. By comparing to "Maslow's hierarchy of needs", making things beautiful is a solution at the top of the pyramid, which is useful for certain types for experiences, but for other experiences other values are sought. What is experienced as beautiful in a certain experience is rather subjective to the user, and dependent on the functionality and purpose. This indicates the importance of understanding the user's needs and concerns, as these in the end are most responsible for the evaluation of any experience.

Haptics and sensorial design

Feet haptics

The feet are in constant contact with the surroundings, constantly gathering information used to keep the balance and help the walking (Velázquez et. al., 2012). However, the feet also offers information about the environment one is in, informing about the body's position in relation to this. To be able to do this, the foot can handle big pressures and be resilient, while at the same time offer flexibility. On the other hand, the feet are not that sensitive to shifts in temperatures, being the least sensitive body area to this (Jones, 2009).

Even though the feet are not the body area which is most sensitive to haptics, Velázquez et. al. has found that vibrating patterns can be easily identified, where vibrations are being part of the category of pressures. When applied to the feet, people digest this into information, associations and emotions, which was used for navigational purposes by Velázquez. It is also highlighted how the vision is affecting the accuracy of what is perceived by the feet, since blind individuals was found to be more accurate in interpreting vibrations than seeing ones. Velázquez et. al. concludes that even though vibrating patterns can be used, complex, precise or detailed information is difficult to perceive. While complex patterns can be hard to interpret, by adding more cognitive workload, natural associations and metaphors can be used to lower the workload while still offering a correct identification (Rovers and van Essen, 2005). Overall, this indicates that the information given by the feet is important for what is perceived, however not having to be complex to be useful.

Tricking the brain with sensorial design

The phenomena of VR by itself means tricking the sensory perceptions, by creating a perception of being moved from the real world to a virtual one, which is experienced as if it was real. Besides tricking the senses of vision and hearing, there is also "redirected touch" (Kohli, 2013) and "redirected walking" (Hickman, 2016). This means using that humans tend to trust the visual input over all other senses, and thereby what is perceived by haptics might be hacked by using this dominance. As a consequence, what is felt does not have to be the same as what is seen, due to the brain changing the perception of this input according to the visuals. By using passive haptics, meaning static haptic impressions, Kohli proved that the mapping between the real and virtual world is not in

scale 1:1. Additionally, the redirection of the touch and walking is possible since there is a sensory re-calibration process, which means that the brain adapt and re-adapts very quick to changes. However, tricking the brain means an added cognitive load, affecting the task performance and that people tend to feel strange afterwards. (Kohli, 2016).

Another way of simulating shapes or texture has been presented, where lateral forces applied to the hand, meaning pressures or vibrations, has been found to successfully simulating a flat surface as being sharp or pointed, by using vibrations (Robles-De-La-Torre, 2006). Not only was it found possible to create illusions of shapes and textures, but it was also found that people could match the sensations with specific images. The reason for this being possible is again believed to be due to the brain making tradeoffs in the sensory information. Especially when containing small details, as textures do, the information given by pressures will be more important than the proprioception. Similarly, tricking the haptic perception in deformations was studied, by using visuals showing the sought feedback in combination with some haptics, however not being the exactly right ones (Srinivasan, Beauregard and Brock, 1996). By viewing various visuals of the degree of deformation, in combination with different degrees of incorrect hand haptics, the perception was found successfully tricked. This was a specific case of proving how the vision dominated the proprioception, but it was also found that as the mismatch between what was felt and seen increased, entirely new perceptions were created.

In VR theme park "The Void", Hickman uses what is called "untouchable walls" to direct the users when there are passive haptics available, though placed wrong in relation to the visuals. By making objects look un-interesting, this allows passive haptic objects to be present in the real VR space, which are important for a certain stage later on in the experience, without interfering with the experience. The virtual area where these are placed will not attract users, due to them being e.g. un-interesting, un-available or repelling, consequently making this trick possible. By making elements look un-desired to be experienced, this consequently means a way of solving the challenge having to give haptics for all elements in the experience.

This research regarding how the haptic perceptions might be tricked to simplify the given haptic perceptions is most often studied with regards to the hands. As, previously described, the hands are much more sensitive and less conscious to humans than the feet, why such findings are not entirely true for the sensitivity of the feet. However, the interaction between the senses are similar. These insights are therefore useful since they can be seen as the upper limits of sensitivity for tricking the haptic perception of the feet. As a consequence, it seems to be possible to simplify the haptic perception of the feet even more than for the hands.

Previous studies regarding haptics shows the interaction between sensory information. This phenomena is called "interdependency", which means that the senses work together when creating experiences (Dagman, Karlsson and Wikström, 2010). What is perceived is not only formed by the senses, but also has to do with anticipations, where what is expected to be perceive by the senses is greatly formed in beforehand via mental images. A consequence from the expectations given by these mental images, is then

that what is actually perceived can either be confirmed or disproved. "Congruence" means that what is perceived is in harmony with what was expected, though this experience offers little surprise (Ludden, Schifferstein and Hekkert, 2006). "Incongruence" refers to the opposite, which offers a surprise that however might be interpreted as either positive or negative. Related to these terms, the creation of a positive surprise or a "wow-experience" has been approached from a product design perspective (Desmet, Porcelijn and van Dijik, 2007). Since most VR experiences currently relies on the "wow" generated by the immersion, it is of importance to understand what lies behind it. The ingredients for what makes this experience are when appraising a product as positively unexpected, fascinating and positively unfamiliar, but also that a product is evaluated as promising and fit for possession. Even though the excitement of "wow" only lasts until new exciting products arrives, it is added that this excitement in the short term will not only spur a wish to see, but also to use and to own a product.

Ethics and code of conduct

The topic of ethics is naturally raised due to the possibility of stepping into any world and experience is available through the emerging VR technology. Many researchers are highlighting the VR experience's power over the human brain and behavior, which might offer fantastic experiences as well as trauma (Andersson, 2017). Similar for most technologies there are no inner restrictions for what might delivered experience-wise. Great responsibilities are therefore put on the designers of VR experiences, due to that VR opens up the powerful sense of being there in any experience – realistic or not. This is an unexplored territory, since it have not been possible to deliver via any previous technology, but at the same time exploring is what is needed to make use of the possibilities the VR technology brings. Andersson argues that since VR has been called "the empathy machine", the possibility of creating empathy works the same way around, implying that the immersion into highly emotional experiences can create empathy, as well as psychological pain and trauma. Even though the users know that what is experienced is not real, they will unconsciously perceive and react to it as if it is actually happening. Therefore, creating empathy and deeper understandings are just as possible as inducing post-traumatic stress syndromes. The consequences emotionally heavy-loaded experiences can bring always must therefore be considered.

When treating the ethics of VR, the unknown physical side effects are commonly discussed (Davis, 2016), in particular the side effects on the eyesight. That the VR technology puts screens near to the eyes could contribute to the increasing shortsightedness, which increases among children due to more and longer use of screens (Björk, 2014). Additionally, long-term implications on the brain and behavior is also a relevant topic which is less focused upon, e.g. due to tricking the brain which Kohli mentions briefly. Davis also recommends that the list from Oculus Rift of possible side effects should still be regarded as possible until more is known about this area, however adding that common sense should prevail regarding the use of VR at this stage.

Regarding the possibility of psychological and physical consequences, a code of conduct for VR experience design has been put together, found in Appendix 6 (Madary

and Metzinger, 2016). According to Andersson, such an code of conduct is important to make sure that the positive qualities that VR brings outshines the possibilities of the negative. The recommendations are based on the extensive results of Madary and Metzinger, summarized into recommendations regarding scientific VR research and consumer application of VR. The concrete recommendations generally instructs scientific researchers to be extra accurate on investigating related research to what is tested, and also to keep a close collaboration with physicians when designing tests. It also treats the importance of researchers not fueling the VR hype, and to be clear about what scientific progress is made to not induce false hopes. Regarding public use, Madary and Metzinger stresses that vulnerable individuals must not use VR, referring to children and mentally ill individuals. This is especially due to children's perception of reality being floating until a certain age, why prolonged use of VR could lead to a risk of children growing up and not being able to distinguish what is real and not. Viewing risky content is addressed by saying that what is common movie content of violence and pornography will not be experienced similarly in VR, bringing risks of trauma due to the immersive qualities of VR. Risky content is also said to be social hallucinations and avatar ownership, where manipulations of self-consciousness and body could cause deeper consequences. Lastly, it is highlighted that any suffering in a VR experience is real suffering, which is unethical by its definition and that users must be informed of such possible risks before.

3.4 Discussion

In this chapter models, theories and guidelines were presented regarding what is currently known regarding general experience design. These treated visual experiences to some extent, though often holding a holistic approach of what is delivered experience wise. Even though they often concentrate on a visual focus, these present knowledge to how user evaluations via feet haptics take place, since all the human senses interact. Consequently, there seem to be broad possibilities to usefully trick the brain. It is not only indicated that what is felt and seen must not cohere, due to the vision unconsciously being deemed as most reliable, but also that the human brain itself tend to fill in the empty gaps. Using such illusion has already been experimented with for VR experience design, by diverting the user's attention from elements that are difficult to simulate with haptic. A feet haptic accessory could benefit of making use of such illusions, which decreases the demands on an exact accuracy and possibilities to touch all things within the experience. This cannot only be used when generally designing VR experiences, which additionally could increase the workload of creating these, but is also crucial for further research. Incoming investigations should therefore not only treat what haptic stimuli together with visual stimuli means, but also if all haptic experiences are necessary to provide.

Via this literature study, information was presented regarding potential dangers, insecurities and ethic challenges that experiences via the VR technology could bring. These are crucial to have when conducting research and development of all experience design for VR, since it has been shown that users will react to the experiences as if there were actually happening – even though they know that they are not real. Most of these insights stresses the lack of long-term research, and that experience designers always must investigate what implications the experience could induce via the powerful medium of VR. Nevertheless, these insecurities have to be balanced against the broad possibilities offered by this medium, and not restricting the further development due to what could be done. Even though there could be potential dangers when using VR, unknown as this new technology unfolds, it is also important to consider that so has the case been for all kinds of new technology. Also, it is not the technology which is risky, but inconsiderable content filling it. The ethical considerations must therefore always be present, however not hinder the development.

3.5 Conclusion

In this chapter results from literature studies have been presented of what is known regarding design of user experiences and perceptions in VR. This refers to both general knowledge about user experience design for VR, as well as relevant insights regarding human cognition and haptic perception. Maslow's hierarchy of needs has been translated into VR design, stating that Comfort and Interpretability are crucial for whether the experience will be possible to use or even inhabit, while Usefulness and Delight determines if the experience holds any value, further making the user want to come back. This means that creating e.g. "wow-experiences", being a common VR content, attracts users short term but is not useful in long-term.

Regarding the perception of presence, it is said that when there is a perception of embodiment, emotion, activity, social and mental presence within a digital experience, humans will respond to simulations as if they were real. This means that the users of VR will react to experiences as if they were actually happening, even though they know they are not. Similarly, all elements in VR does not have to be designed with realistic accuracy, due to that restrictions of the human brain means that not everything will be made conscious. In the same way, the brain also fills in gaps to make impossible perceptions possible. This opens up possibilities to trick the brain, which can be of use when designing VR experiences, with or without haptics. This refers both to what is seen and what is felt, as well as when these senses and expectation works together. Consequently, given haptics does not have to hold accuracy to what is seen, due to the vision interfering with this perception. Via these illusions new levels of impressions can be created, opening up possibilities of haptic wise perceiving e.g. a sharp edge when there is none.

4

Target group

4.1 Purpose and Scope

To investigate the target groups of VR experiences, the current users and the potential users to come, were investigated. Their characteristics and concerns were investigated via surveys to from an emotional perspective understand the user's perspective of and expectations on VR. Furthermore, what characterizes some specific emotional states was investigated, to learn the characteristics of these which could be implemented in experience design. General insights were retrieved about the specific situations when the feet are used in real life, to understand when feet haptics should be provided and not. All in all, this was useful to understand what feet haptics means for the evaluation of experiences, but also what biases and understandings are brought by the users into the general evaluation and perception of VR experiences.

4.2 Method

Literature study

To understand what is known about the users of VR technology a literature study was performed by making use of some research already made in this area. This was used to understand the current target group, but also to shed some light on which the potential target groups are. These insights were useful to find the right target group for the incoming surveys about the potential target group to come.

Surveys

Two surveys were sent out to offer guiding insights about the current users and the potential users of the VR target group. In common for both surveys were that they consisted of both open questions as well as multiple choice questions. Some of the questions of the latter kind regarded emotional evaluation, and were therefore using an emotional measurement scale similar to the PrEmo tool (Desmet, 2003). This scale was constructed by using emojis, which were considered suitable as there is currently a big adoption of using emojis (seen in Figure 21). The emojis were arranged in an order that spanned from one half of positively associated emotions to neutral-positive, and the other half of neutral-negative to negatively assosciated emotions.

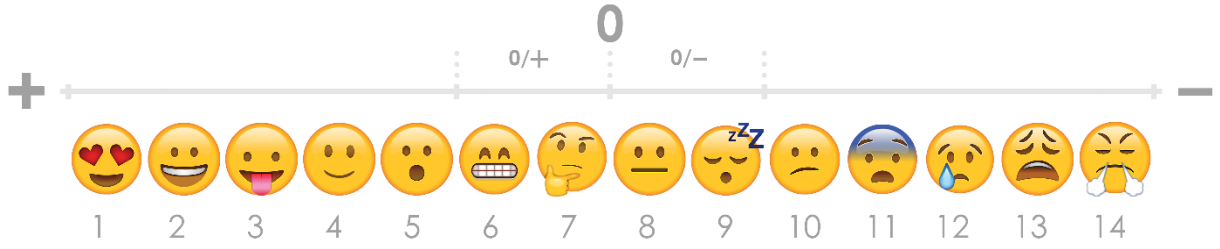


Figure 21 The emotional measurement scale used in the surveys.

Some of the questions regarding emotional evaluations were treating how the user experience of the VR technology as a product has changed over time. Furthermore, this data was compiled into a User Experience curve (Kujala et al., 2011), being such a methodology of compiling change in user experience over time into a curve.

The first survey was directed towards the current users, which are the ones having the most experience with using VR (Appendix 7). This survey was spread via different online VR forums, as well as by tracking down experienced users and further making use of these often knowing others of this kind. To reach these experienced users, the survey was directed towards both individuals owning VR equipment as well as those developing VR experiences. This sample was chosen since the qualities of VR being such a new technology means that the current users are often those interested in developing or exploring this technology, except only using VR for what is offered right now. Consequently, the survey was not only meant to investigate what problems are experienced with the VR technology today, but also what characterizes the current users, their measures of evaluation and expectations regarding VR. By doing this it was possible to determine if there are certain biases or attitudes. Such was deemed of interest to investigate since these users concerns shapes the development, however these concerns could differ from the attitudes and measures of evaluation of the incoming potential users. To furthermore reach out to this sample, the survey was directed both particularly to individuals known owning or working with VR equipment, as well as in a more openly directed to these via specific VR internet forums.

The second survey was directed towards the potential users to come, where the sample of responders that was directed was based on the result of the literature study (Appendix 9). Based on this, they were targeted both specifically in terms of users known to be potential users, as well as openly directing this target group though different social media channels. The survey was also sent out to employees at DigitasLBi not being those working with VR. These were chosen due to them aligning with the results of the literature study of who the potential users are, but also due to them belonging to the group of individuals that comes in contact with the use areas where DigitasLBi typically launches their VR experiences, e.g. fairs. Similarly to the first survey, the second survey was further investigating characteristics, expectations and concerns regarding VR, but also what they are consciously aware of regarding how they use their feet. This was of interest to understand what and what not the potential users could be using their feet for in VR experiences, and what they want to experience or not. Furthermore, questions were also asked about how much time is spent daily with various screen technology. This was of interest mainly to understand how many "languages of interaction" that are managed simultaneously, which affects how well a new language of interaction might be adopted.

The second survey also meant to briefly guide into what factors means elicitations of certain emotions, which the evaluation of and performance in VR experiences are highly affected by. This was manifested through questions about what characterizes real life circumstances that puts them in certain emotional states. Lastly, the emotional states that was investigated were distinct emotions that were deemed as having the greatest impact on the evaluation and performance in VR. Altogether, these insights about the target group together with what makes these certain experiences were deemed to form a framework of considerations when creating VR experiences.

Personas

To summarize and make representations of the current and potential users, design personas were used which further described goals, behaviors and considerations of the users (Cooper, 2015). The personas were represented by characteristic ages and occupations, typical held opinions and scenarios involving typical user properties and considerations. These personas were consequently useful when creating the guidelines and requirements, as well as when designing the final concept.

4.3 Result and Analysis

Current users

Characteristics

Via the previous trend analysis of Buckle and Mander, the current target group of VR has briefly been described, stating that these are early tech adopters. Being an early adopter is explained by the curve and theory of "Diffusion of innovations", which explains adoption of products and technology among different user groups according to time (Rogers, 1962). Early adopters mean a smaller fraction of all the users, 13,5%, whom consequently are early off in exploring and using new products and technologies (seen in Figure 22). Apart from this, Buckle and Mander mean that since only this small fraction of users has been reached so far, interests of the users is important when developing the VR technology and experiences. This also means that what the potential users are interested in regarding VR is more important than only fulfilling the wishes and needs of the current users. However, as the current users have valuable experience of VR and since their considerations affect the development of VR, investigating these users are of high

interest.

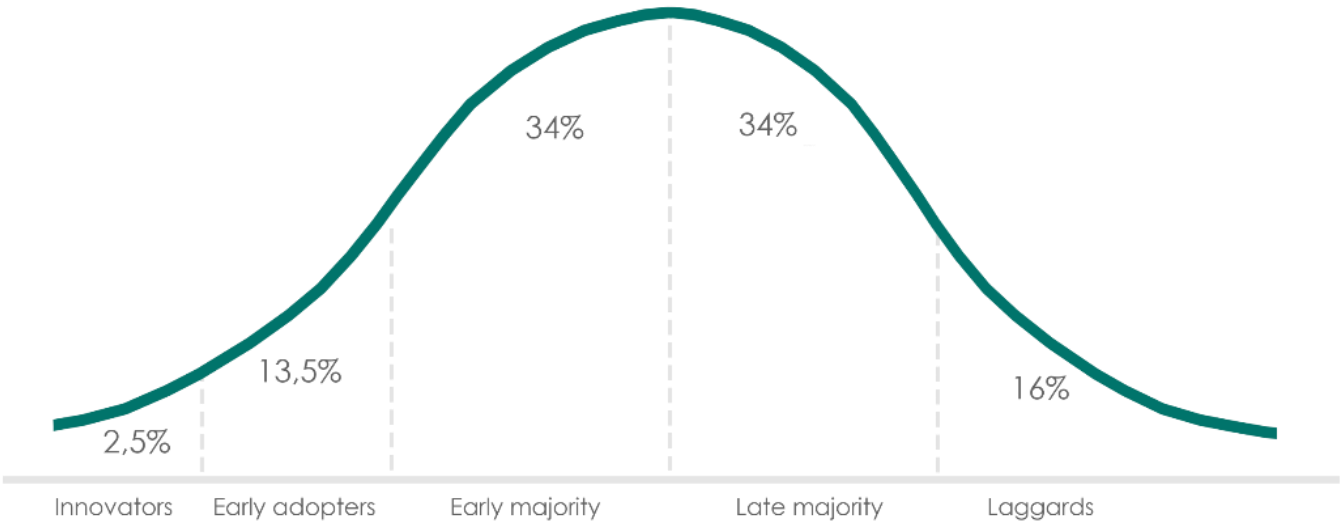


Figure 22 The curve of the Diffusion of innovations.

The generated 18 responses of responders from various countries over Europe and North America, and offered some insights about who the current users are and their considerations regarding VR (found in Appendix 8). The results proved that the current users affect the development of VR, since a majority stated that the VR equipment was bought to experiment with or just to create things for VR, except using VR for working purposes (presented in Figure 23). These users are also characterized by being somewhere around 30 years old and having tech-oriented interests, education and/or occupation - most often all of these at the same time. The enthusiasm means not only that they are motivated to buy VR equipment, but also that their technology orientation in occupation and higher education indicates that they can afford buying VR.

"BECAUSE VR IS AWESOME." [ABOUT WHY THE VR EQUIPMENT WAS BOUGHT]

Regarding the actual use of VR experiences and those that are returned to are experiences being entertaining ones, primarily games, but also the ones displaying the technology. For the technology displaying ones, these are returned to due to them offering understanding, learning and inspiration, but also for showing VR first-time users VR. Coming to the types of VR equipment that are used, many of these users have access to different high-end VR equipment, however Google Cardboard is the most frequently owned equipment. This might be due to the early availability of this product and its inexpensiveness, indicating that even though these users are VR enthusiasts their gate to VR was also mobile VR. Lastly, on specific questions about haptic feedback to VR it was said that offering haptics is good, however some stated that this needs to be thought through as not every experience is sought to be haptic.

"MOSTLY I RETURN TO SELF-MADE THINGS, BUT I LIKE THE LAB AS A FUNNY SHOWCASE TO SOMETIMES SPEND SOME TIME IN, STUDYING THEIR IMPLEMENTATIONS."

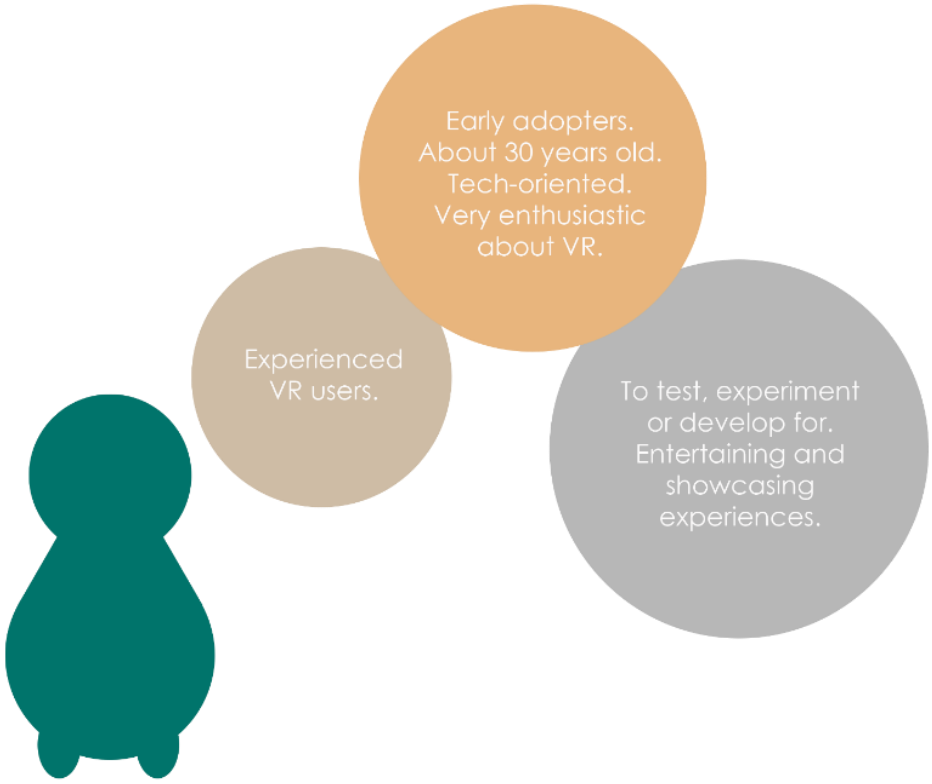


Figure 23 Figure describing the characteristics of the current VR users, and what they use VR for.

Problems

About problems with VR equipment and in experiences the users expressed themselves very tech-oriented about the demands, summarized in Figure 24. However, what was often asked for was experience design related aspects or aspects that will be improved within a near future, by e.g. better visual quality and cordless HMDs. This meant that problems most often mentioned were motion sickness followed by the cable management and general HMD comfort improvements. In addition to this, it was also common to state that the content needs to improve, as well as that the pricing was a big obstacle when trying to reach more users.

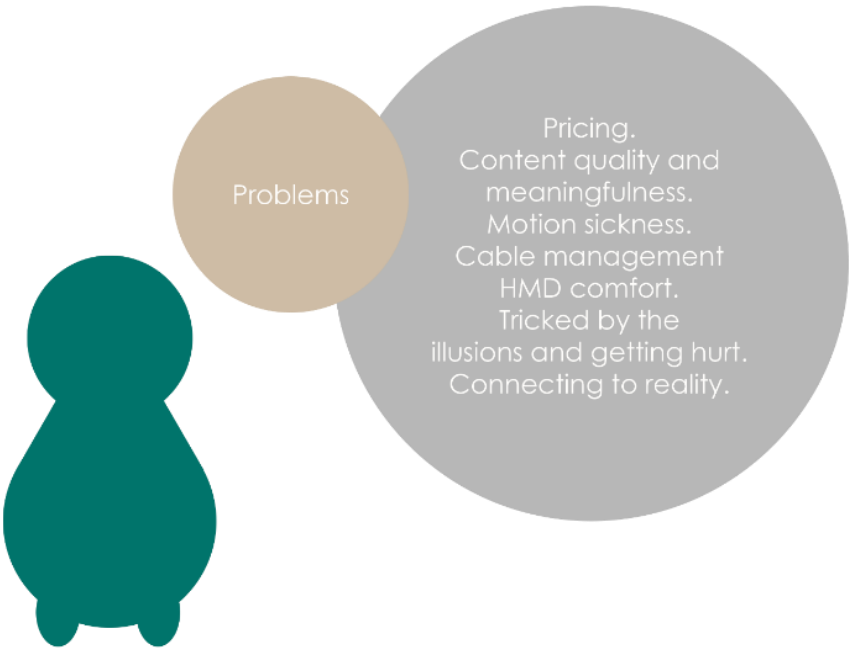


Figure 24 General problems perceived by the current VR users.

Another type of problematics was found in terms of that it is very common to being tricked by the illusions of VR. This means e.g. trying to lean on something that is not there, avoiding things by instinct, leaning on things or forgetting about the guardian grid. Commonly, some of these mind tricks lead to hurting oneself or others. Even though getting hurt is not pleasant, the responders expressed that this is experienced as amusing or interesting, rather than the strongly negative emotions usually associated with this. This positivity was likely due to that these individuals are very enthusiastic about this technology, which was seen throughout the majority of the answers. This further meant that feedback that could be interpreted as negative regarding the future of VR was sparsely mentioned.

"I'VE RUN INTO WALLS, TRIED TO LEAN ON OBJECTS, PUNCHED A TV WITH THE CONTROLLERS. YOU DON'T THINK IT WILL, BUT SOONER OR LATER, YOU WILL BE IMMERSED ENOUGH TO FORGET."

"WHEN I WAS STILL NEW TO VR AND WAS SPENDING A LOT OF TIME IN IT, WHENEVER I LEFT THE HEADSET I WOULD FEEL LIKE I HADN'T REALLY RETURNED TO REALITY. I'D SOMETIMES REACH FOR CONTROLS OR GESTURES FROM THE GAMES OR JUST SIT THERE FEELING AS IF THE WORLD WERE STRANGELY FAKE. EVENTUALLY THIS WENT AWAY."

Even so, two respondents of the survey brought up problems regarding psychological effects after using VR, which touches upon the unknown territory of long-term consequences. These effects were referred to in terms of nightmares and connecting to reality after VR use, also saying that this was only experienced in the beginning. These psychological effects of VR use were also indirectly expressed via that the users were easily tricked by the illusions of VR, even though them knowing that it is not real. Similarly to what is stated in "the theory of presence" this confirms that reactions to events in VR many times take place as they do in real life, no matter how much we know that these are not real.

Expectations

The enthusiasm reflecting in the answers, meant that there is a very active bias present with the current users. This primarily manifested in the emotional questions, which were answered with the emotional emoji-scale, and further were compiled into a User Experience curve (Figure 25).

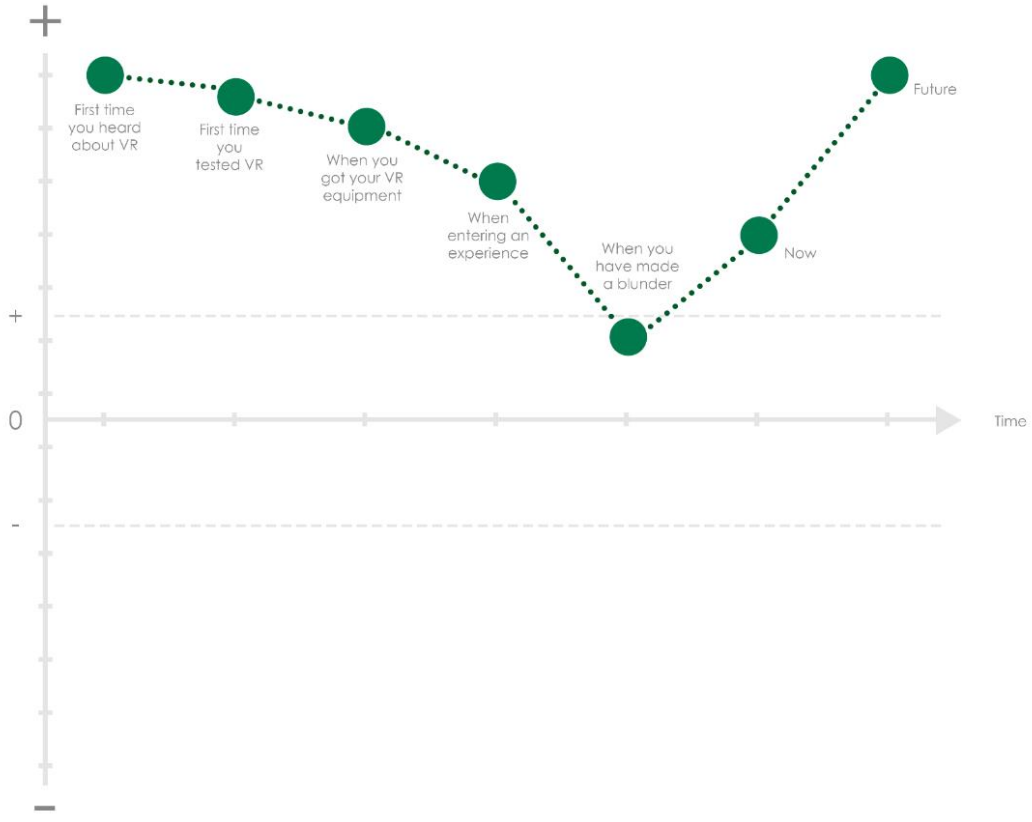


Figure 25 User experience curve of the current VR users.

Throughout this curve, most experiences were evaluated as positive, which is due to these users being very engaged in this technology that everything is evaluated as rather positive. What sticks out is that the emotions were most positive in the introducing phase, as well as for the future. This was also seen in other questions about VR where high expectations were expressed as well as no doubt that this is the future. Comparing these emotional expectations, there are a slight dip when entering a VR experience and about what is currently felt. This is indicating that the expectations are not met from was earlier expected but also about what is to come. That these users are very tech-oriented, which generates this enthusiasm of VR, means that current faults are over-looked since these types of users understand what might currently be expected of this technology. This also offers an answer to that they do not criticize the technology for not meeting their expectations as it is right now. As previously found, blunders and surprises due to being tricked by the illusions of VR are also evaluated as positive. Even though these might be a bit interesting or fun the first time, it might not be sustainable in the end. This indicates that the current users are not evaluating VR experiences similarly as other groups of users would, as summarized in Figure 26. However, as the User Experience curve also indicates, there are high expectations of the potential of VR, furthermore establishing that VR has a lot to live up to in keeping these users' enthusiasm. For this purpose, experience design is the key.

"IT WILL CHANGE THE WAY WE LIVE OUR DAILY LIVES, AND WHERE WE LIVE THEM. DE-URBANIZATION?"

Figure 25 The bias of the current VR users, which affects how VR, and its experiences, are evaluated.

Potential users

Characteristics

As shown in the "Diffusion of innovations" curve, the current users of VR are only a small fraction, which is due to the newness of this type of technology. The purpose of the VR experience design is therefore important to consider, so that the delivered content is what the future users are interested in, according to their characteristics and concerns. Buckle and Mander states three facts about the potential and incoming users of VR, being that the younger, the higher income or the more interested in gaming the more likely one is to be interested in using VR. It is also stated that these potential users are most likely to be urbans. According to expressed interest in the investigations of Buckle and Mander, this target group of potential users might further be divided into two sub-groups, which are likely to be the soon to come users. Being sorted on age, one sub-group are urbans from 16-24 to 25-34, while the other sub-group are urbans of 35-44 years old (seen in Figure 27). The younger group is generally keener on trying out VR, however expected to be more price sensitive than the older one. Altogether, these have in common that quality, meaningfulness and availability are the keys to reach these users. A conclusion can however be drawn that a positive attitude and acceptance of new technology are crucial for them to be reached at all.

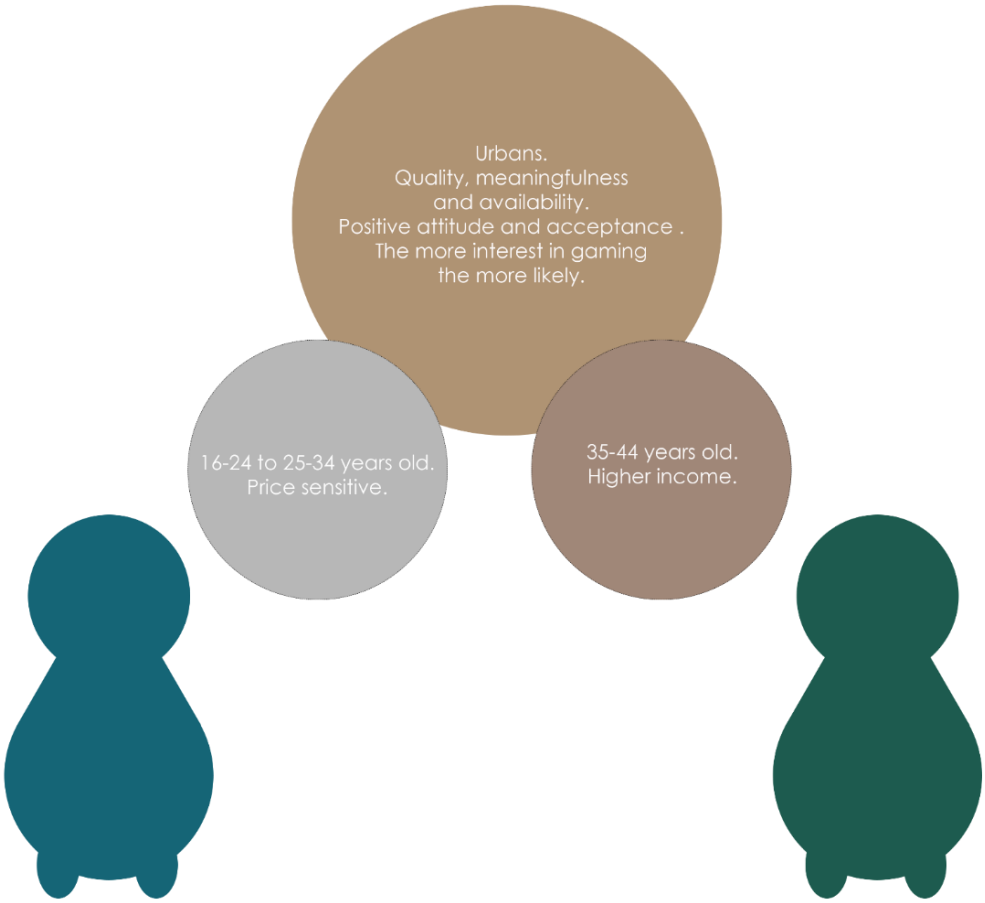


Figure 26 Characteristics of the potential VR users.

For the survey directing to the potential users, 41 answers was retrieved from responders of primarily Swedish background. The majority of these belonged to the younger half of the target group, but the older half was also reached. This has to do with how the sample of respondents were reached. From the results (found in Appendix 10) it was found that studying is the primary occupation of the younger half, having to do with that many tend to study while in their 20's. If not studying, having some kind of higher education or slightly technical occupation is also common. As for the older half, there where no one studying, but all worked with some kind of office work, spanning from being purchaser to software developer. Regarding interests of the responders, both halves was interested in all physically active and outdoor activities, but also social and various creative activities e.g. music and art. Different types of technology were also of interest, particularly gaming and other types of "technical" entertainment. What differs between the halves of the target group were that the older half was much more orientated around family and home, which was also reflected in all the other responses. As for the younger half, these assigned with a bigger frequency that movies and gaming were their interests.

"IT'S EXCITING AND HOLDS ENDLESS OF POSSIBILITIES BOTH IN WORK AND PLAY."

Regarding experience of VR use, most of the social media sample group had no experience or very little experience with VR. The sample group of the DigitasLBi office naturally had more experience with VR, due to them working with VR and having VR equipment available at their office, why these responses are misrepresentative regarding the general experience. When being asked to pick an emoji representing how they feel when thinking about VR, positive emotions about VR was commonly expressed for both halves of the target group. These spanned from "Wow" to happy and exciting emotions. Again, the DigitasLBi sample group differs slightly, by them being more positive in their expressed responses than the social media sample group generally was found to be. Therefore the social media sample group might be seen as more representative in general for this target group.

"IT IS COOL BUT I DO NOT KNOW WHAT TO DO WITH IT?"

When explaining why they felt this way it was generally said to be due to the huge potential the VR technology brings, as well as it is the future, cool and interesting. However, several also discussed VR in terms of the need of meaningful content and actual usefulness. Some also touched upon that it is a bit in gimmick mode with a bit of hassle to it. A small group of individuals also expressed more negatively put concerns about VR. These considerations came in terms of that VR was perceived as anti-social and scary, but also by hoping that VR will not change the way we live by

"I DON'T LIKE THE FACT THAT YOU ISOLATE YOURSELF FROM THE PEOPLE AROUND YOU, WITH THE CURRENT APPLICATIONS THAT I KNOW OF, WHILE EXPERIENCING VR. I LIKE TO BE MORE SOCIAL."

turning too big. Some added to this that they already think a lot of time is spent looking into our smartphones, and that they do not want VR to add more to this.

"I THINK IT WILL DEVELOP, BUT I HOPE IT WON'T TAKE OVER FROM OTHER EXPERIENCES AS WELL."

In the multiple-choice questions regarding context of use and use areas they would be interested in using VR for, entertainment, education, business science and industry scored the greatest interest. Almost everyone wanted to use VR for entertainment in particular, which might be due to that this is primary what VR is used for right now. As for the other use areas assigned, these were highly functional use areas, rather than semi-entertaining experiences as e.g. shopping or travelling. However, all use areas generally score high in interest, indicating the futuristic and high expectation-approach of VR. Regarding context of use, spanning from being alone to being with others, most responded that they would feel comfortable in all contexts. Even though many assigned this, using VR with strangers was something that sticked out by being perceived as uncomfortable by half of the responders. Additionally, some of the responders also assigned that using VR alone was something they would find uncomfortable. Comparing the halves of the target group, the older half was slightly more uncomfortable with using VR alone than the younger one. Furthermore, the older age group general expressed a cooler degree of positive emotion and excitement about VR, while the younger generally expressed a more distinct "wow" emotion around VR.

Expectations

"IT'S STILL IN A GIMMICK PHASE - A COOL GIMMICK - BUT I'M NOT SURE HOW IT WILL DEVELOP."

Regarding the expectations of the future role of VR similar patterns as previously seen was also observed, where many expressed high expectations though many also questions VR. This generally wraps up how VR was perceived by this target group. VR was perceived as highly futuristic and there are high expectations on everyday usefulness and functionality. However more negatively put expectations are also commonly expressed, either that it is just another gaming thing, and that VR needs to be less gimmicky to actually make it (bias summarized in Figure 29). Specific responders also discussed risks that VR might be misused as a technology, and also explicitly stating that they hope it will not break through. This bi-polarity in expectations of the future is consequently seen in the User Experience curve compiled from the responders assessing what they feel about VR right now, relatively what they expect to feel about VR in the future (Figure 28).

"IT IS JUST ANOTHER GAMING CONSOLE OR ACCESSORY THING."

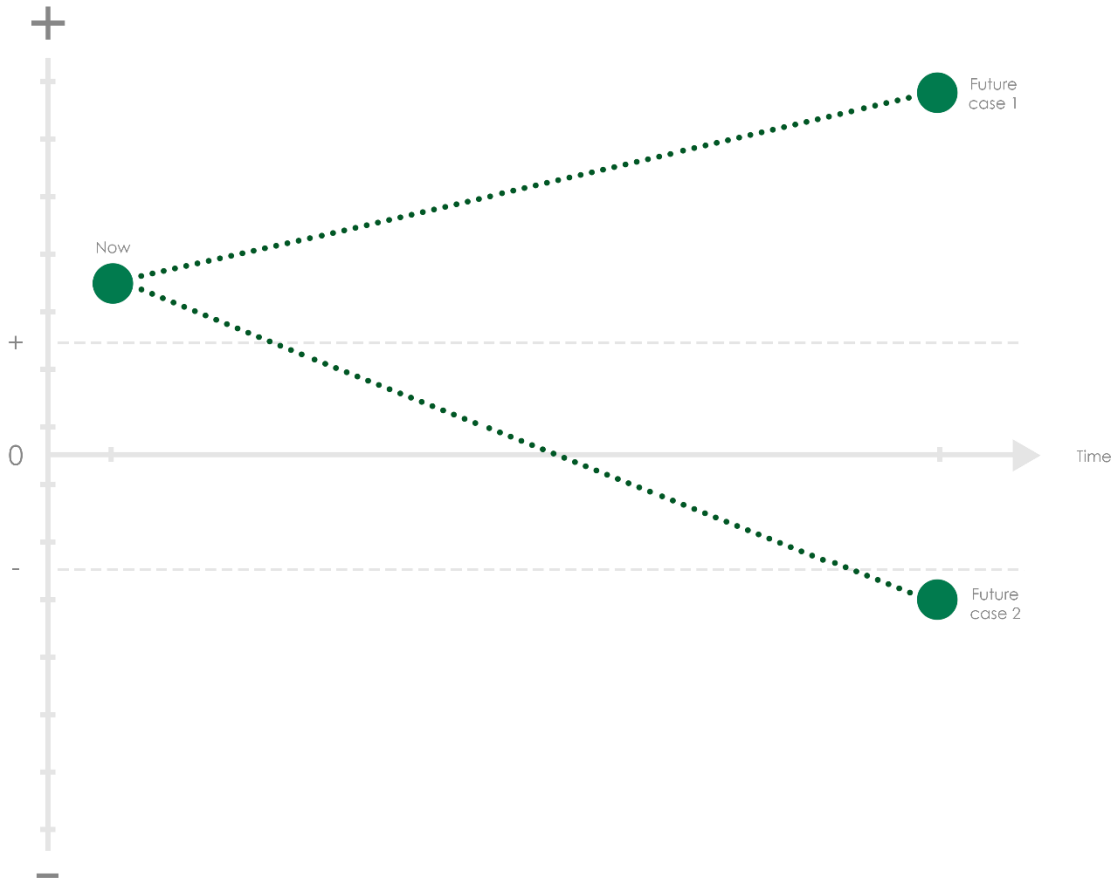


Figure 27 User Experience curve of the potential VR users.

The User Experience curve (seen in Figure 28) was created from the emotional questions answered with the emoji-scales. Generally a sober positive emotion regarding the VR of now was expressed. Depending on the future of VR, this perception was assigned by the respondents to change, to be either highly positive or slightly negative. According to the respondents, this is not only determined by content quality and meaningfulness, but also how the future use of VR will affect the users' lives and the extent of this.

> "I THINK VR WILL HAVE AN IMPORTANT ROLE IN SOCIETY IN THE FUTURE, BUT I DO NOT BELIEVE IT WILL BE SOMETHING PEOPLE USE IN EVERYDAY ACTIVITIES. IN VR YOU TRAVEL TO AN ALTERNATIVE REALITY, AND I DON'T THINK YOU HAVE REASONS TO DO THAT ON AN EVERYDAY BASIS. BUT STILL, IT WILL HAVE AN IMPACT IN SOME WAY..."

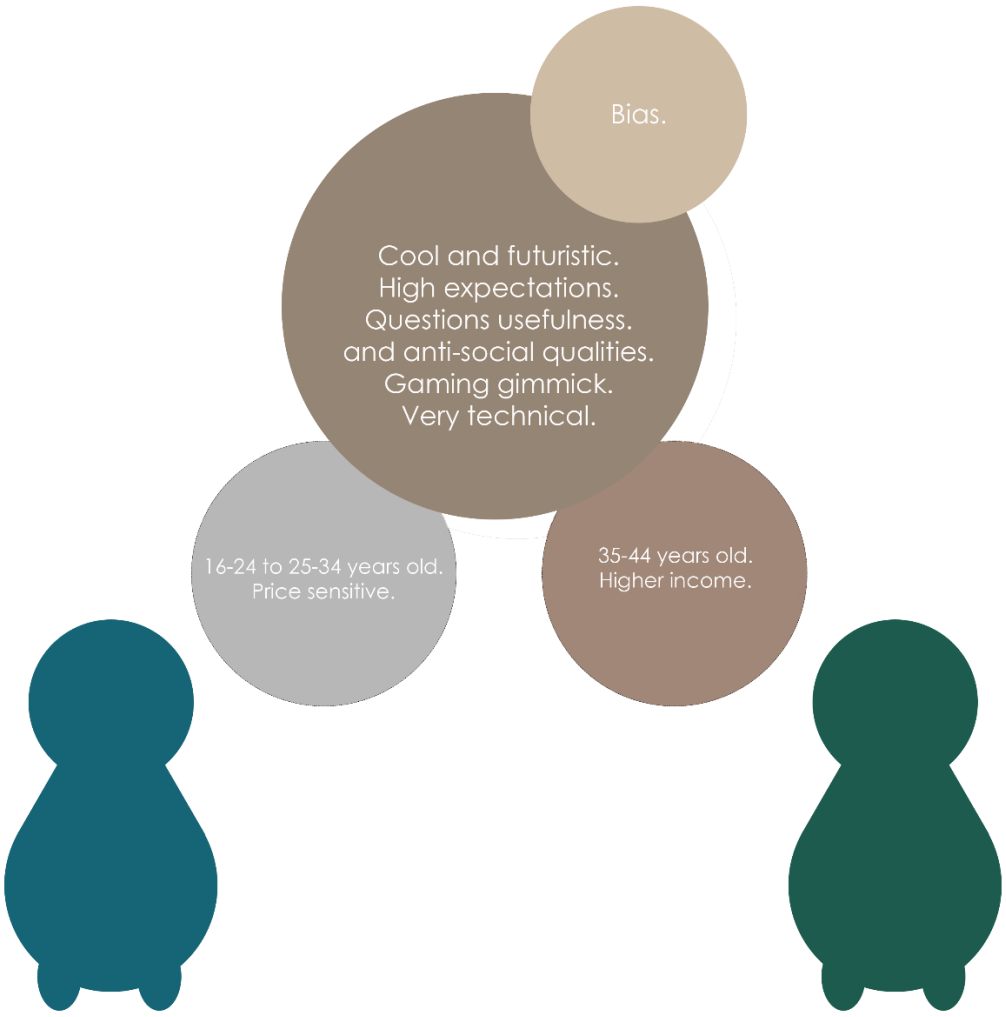


Figure 28 The bias of the potential VR users, which affects how VR, and its experiences, will be evaluated.

Real life factors relevant for Virtual reality experience design

Uses and experiences of the feet

From the survey information was also elicited regarding how the feet are used and experiences given by this body area (found in in Appendix 10). Except obvious usage for being stable and holding a grip, the feet were generally said to be used to investigate and understand materials and objects placed on the ground. This is rather logic due to that as for some cases, the feet are more suitable to use than other body parts, e.g. to investigating objects that actually are placed in foot height. However, it was strongly indicated that the feet are used in a rather "sacrificing" manner to investigate suspicions, risky or icky things. This is due to that one rather risks the foot first to understand what is to be expected, than

"I TURN ON AND OFF MY AMPLIFIER AT HOME THAT STANDS ON THE FLOOR UNDER MY DESK WITH MY FOOT. NOW I DO IT WITHOUT LOOKING AT IT."

risking more important body parts or the whole body. Similarly, the feet were said to be used to find the way when sight is limited or when the light is very low, as well as reaching for things. A conclusion can be drawn that we have learnt to use the feet for certain things, as the feet are sensitive enough to offer information, yet less sensitive to be the most vital body part. Therefore, the feet might be put at risk investigating some ground properties without risking other more vital functions of the body.

"I RECENTLY USED MY FEET TO POKE SOMETHING TO SEE IF IT WAS ALIVE. OR TO CHECK IF THE GROUND WAS STEADY ENOUGH TO SUPPORT MY WEIGHT."

To understand if there are some experiences that should be avoided to give haptic wise, as well as which could be used to make experiences more likeable, explicit questions were asked about what characterizes such experiences, as well as if there are anything particular that tend to be avoided:

Pleasant

Except obvious things as massage, pleasant feet experiences are smooth and soft materials and touches. Most often these are such that has some analogy or association to them, e.g. a notion of freedom, summer, vacation or coziness.

Unpleasant

Painful experiences are naturally unpleasant, however grounds that are dirty, crumbly, wet or sticky and particularly the combination of these altogether, also characterize unpleasant experiences. Many also perceive tickles as unpleasant, while some perceive uncertainty of what is felt, or the consequence this uncertainty, as unpleasant.

Avoided

Related to what is perceived as unpleasant, people consequently avoid these experiences. Additionally, being barefoot outside is also avoided, even though many expressed being barefoot as being pleasant. This was said to be due to having learnt that threat of stepping on something unpleasant and due to not being used to being barefoot.

Circumstances of emotional apprehensions

How experiences given by the feet are perceived was generally investigated to get a view upon what situation will generate certain emotions. In a loop, such emotions in turn affect the perception of what is experienced. As previously mentioned, dominating senses with input implies that strongly emotional experiences could make feet haptics unnecessary and even unwanted. Consequently, briefly knowing what makes strong and clear emotions in real life is highly applicable when creating any VR experience, and can be used as predictions about what elements and interactions that could generate certain user reactions. Through the survey, the following properties were found regarding what puts the responders in certain emotional states:

Confidence

Confidence is created when feeling like the expert in the area, through either knowing that one is good at this or by getting feedback about this. Knowing what is expected or familiarity also is a criterion for confidence. Additionally, being in a context of with family, friends or relaxing at home is also circumstances that creates this emotion.

Unconfident

Territories where knowledge and experience is lacking are situations that create unconfidence. This has also to do with social circumstances of unconfidence, as talking with new people and not understanding the social situation. Similarly, new places, not having control and generally leaving the comfort zone by e.g. doing things that are new or perceived unpleasant are circumstances which will lead to an unconfident emotion.

Relaxed

Similar to the situation of confidence, the situations where people are relaxed are at home and with friends and family. This also means leisure time, relaxing in any way, accomplishing things and wrapping up the day.

Stressed

The other way around to when feeling relaxed, stress occurs when there is too much to do, and generally the threat of a time limit hoovering over you. Additionally, various social situations elicit stress, such as quarrels, crowds, being questioned, new or tricky people.

Happy

In relation to feeling confidence and relaxed, happiness is perceived when being with family and friends, performing the hobby and generally receiving any feedback that makes one feel good about themselves.

Scared

Situations leading to feeling scared are being in dark places, feeling unsafe in any way and the threat of people close to you being hurt or dying. Some explicitly assigned horror movies and similar as where they feel scared, adding that they do not find such experiences entertaining for this purpose. Similar to situations of stress, feeling scared as a response to social situations was also mentioned. This referred to e.g. being judged by others, conflicts or generally being in the presence of other people whom they perceive as unreliable or unpredictable.

As previously mentioned, there was a difference seen between the halves of the target group, being that the older age group was more orientated around their family and home in all subjects. This family and home orientation is seen from interests to describing the situations of being relaxed and happy, but also around what scares them. This is a natural consequence of being likely to recently having kids or having kids living at home at this age. Also almost everyone in the older age group explicitly described feeling

confident when being at work, which differs from the younger group when they are describing the circumstances that makes them feel confident, where their occupation or situations of performance is rarely mentioned.

Screen technology patterns and adoption

Information was gathered regarding which types of screen technologies that was most frequently used and integrated in everyday life (found in in Appendix 10). The smartphone and laptop were found to be most frequently used, where these screen technologies most often was the private ones, except for some cases of the laptop. Over all, the smartphone was assigned to be used by everyone, and also for a longer time daily of about 2 hours. However there is always another screen technology present in combination with the smartphone. Most often this is a laptop, which commonly is used for longer periods of time for some to e.g. study. However, if you are not working the smartphone will be where most time is put. If you are working, you will be more likely to spend 6 hours or more with a professional laptop. A PC might be used instead for a laptop, which seems to have to do with what you want to do with your computer, e.g. gaming. For a smaller fraction of the responders, the TV was also used a lot, and for some a tablet was also present. Even so, a tablet never used at all for many users, which was likely due to the smartphones rivaling with the tablet.

For this research, this means that the target group has great experience of different screen technologies and their corresponding languages of interaction. Furthermore, the users switch between these on a daily basis, meaning that they are controlling several languages of interaction simultaneously. This is probably learnt over time as the technologies has been integrated into their lives, further implying that the target group could be open to handle another language of communication which any interaction model of VR will mean. However, it has to be considered that some time will be spent on adapting to this new interaction language, as it will probably differ a lot from how interaction is performed with current screen technologies.

Comparing the targets groups

When comparing the current users and the potential users of the target groups, there are as expected differences between these, summarized in Figure 30. The potential users are expressing a cool degree of positivity to VR, which differs from the big enthusiasm of the current target group. Consequently, the potential users are more questioning and want to discuss how actual functionality will work and how their lives will be affected by this. Comparing this to Maslow's hierarchy of needs, the current users currently are satisfied with the two lower levels, which refers to the basic functionality of comfort and interpretability. This is a consequence of these users understanding what might be expected of the technology in the present situation. The potential users demands are on the other way around located at the top of this pyramid, referring to demands on usefulness and delight. This means not only expectations on that there will be quality content that brings meaning and something extra, but also that little indulgence with hassles and time spent on solving this. Furthermore, this is most likely a consequence of the hype around VR which has led to big interest in this technology, but also that the incoming users expect all things to just work and hold high functionality and quality. The situation is therefore that allowing users to step into any virtual world has just recently been solved technically, which clearly means new possibilities in use. Due to this, the phase where content and functionality is explored and invented has just been entered is something that clinches with the expectations of the incoming users. Simply explaining the expectations on VR, this means that the wheel has just been invented - but the incoming users expect a family car. This means that the users expectations on the potential to VR both could work in its advance as well as being a threat.

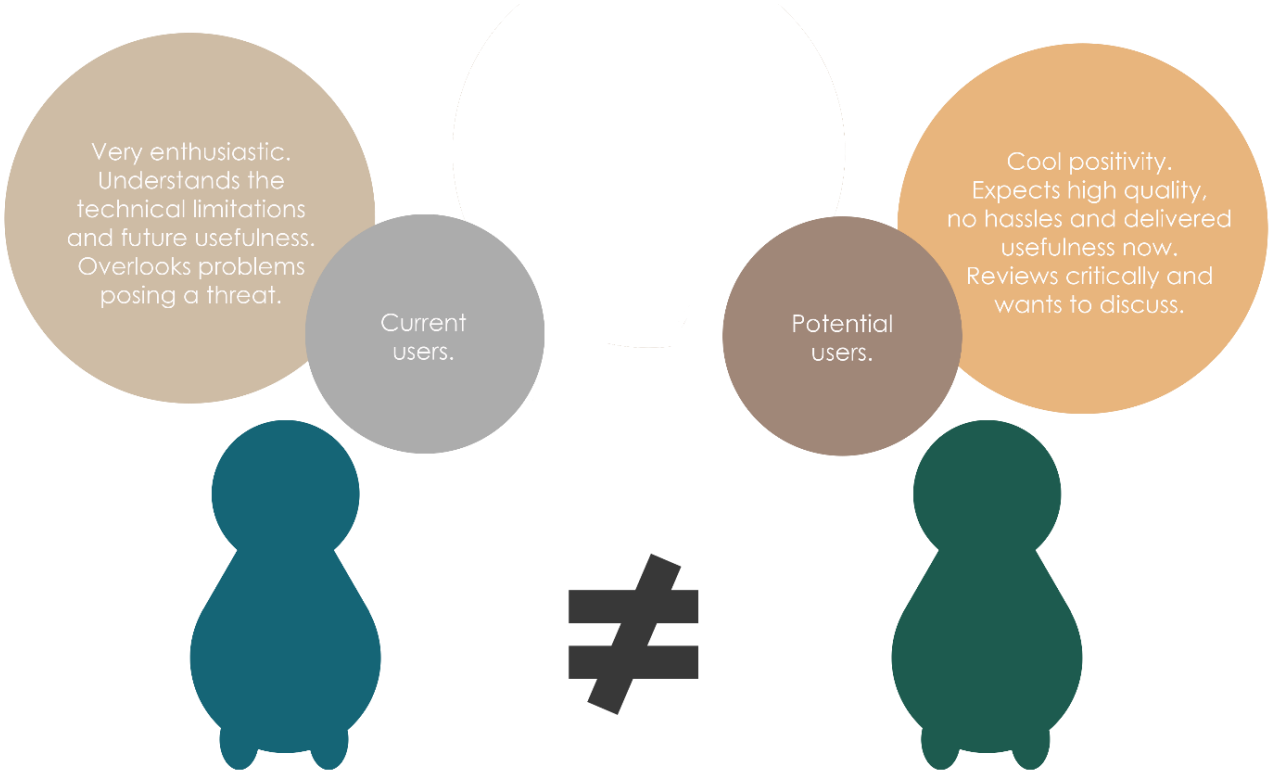


Figure 29 The differences between the current and the potential target group.

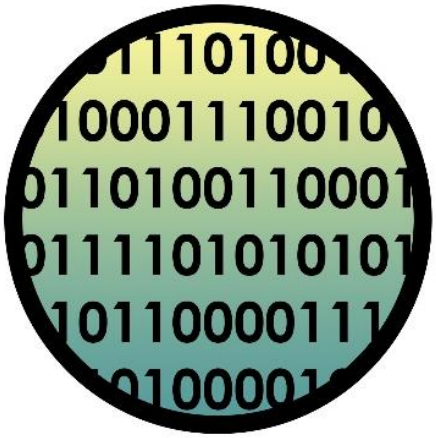
Regarding the case of DigitasLBi's customers and their users, it seems more likely that the users most commonly targeted will belong to the older half of the target group (summarized in Figure 31). This has to do with the common use areas of the experiences, as it is common that the experiences comes in the form of showrooms or events. Therefore it is more likely that these use areas will attract urban adults, rather than young urban adults and teenagers. Furthermore, this target group mean individuals characterized by being interested in VR, however not that easily is tagging along the hype of VR. According to this, VR experiences will be reviewed with a more critical eye in comparison to how the current users are evaluating VR experiences. This target group has however a bigger confidence about using VR with others than the younger half proved to have, however not that inclined to use experiences alone. Lastly, as this half of the target group is more concerned around their home and family, they might be more protective around elements associated with such values.

Figure 30 The specific target group of potential users of DigitasLBi.

Personas

Current user

- Michael
- 32 years old
- Software developer
- Owns a HTC Vive and a Google Cardboard



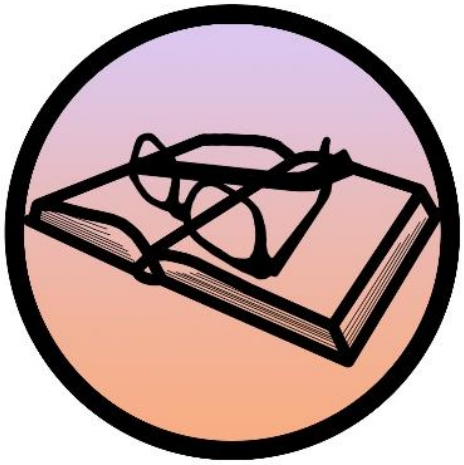
It is Friday afternoon and Michael is at home in his flat, sitting by his computer and experimenting with his VR hobby project. Some months ago, he at last received his HTC Vive, after previously trying it out at a job event with his colleagues. Until that first test of high-end VR, Michael had been experimenting with his Google Cardboard and had read much about VR in various online forums. However, trying out VR at that event was a game changer for him – what possibilities that lies at hand with this technology! The following day, Michael started saving up to buy the HTC Vive that just been launched and join the immersive revolution. Of course, there are problems with the technology, as tripping on the cable, motions sickness and the classic of bumping into things due to missing out the guardian grid. But these problems will naturally be solved as VR develops.

The immersion into his project breaks when the doorbell rings. His friends are arriving to try out VR during their traditional Friday after work. They have been anxious about trying it out ever since he bought his HTC Vive, and Michael is excited to see their reactions when trying it. He starts a showcasing VR experience and settles in the sofa with a beer while one of his friends enters the experience. His friend reacts with awe, and accidently trips on the TV table when startled by a figure in the experience. They laugh, and so the evening continues while everyone agrees upon that this has to be the future of computer technology.

"VR IS THE FUTURE OF HOW WE WILL DO ALL THINGS AND INTERACTIONS."

Potential user in span 16-24 and 25-34

- Emma
- 25 years old
- Studying business economics
- Tried Google Cardboard once



Emma is sitting at the university library, studying for her incoming exam. A job fair that is going on in the other halls is turning louder and louder, breaking her attention. The messenger chat blings, as one of her friends eagerly tells that one of the companies at the job fair has brought VR equipment to let students try it out. Emma responds that she already tried VR once, a bumpy and low-resolution rollercoaster experience, via a friend's Google Cardboard, which left her nauseous for two hours. Her friend eagerly responds that this is not the same - this is *real* VR. Since there is no concentration left for studying, Emma decides to meet up with her friend and check out what this *real* VR means.

At the job fair, the company that has brought a HTC Vive are surrounded by a small group of students, looking at one of the company employees playing a VR game to demonstrate how it works. After finished demonstrating, Emma is persuaded to try it out as her friend turned too shy to try it out in front of the crowd. After some hassles with getting the equipment on, and trying to figure out the functionality of the hand controls, Emma enters the experience. She reacts with awe to what she sees; it feels like she is actually there! She gets so amazed by the details of the out-of-this-world setting she is in, that she misses that the game has started. Consequently, her non-existing body is suddenly impaled by several high speed fire-balls, making her instantly react with throwing herself on the ground. The experience proclamates that it is game over. Emma is laughing slightly embarrassed of her reaction as she takes of the headset, while one of the employees comfortingly says that this always happens.

Taking off from the job fair, Emma tries to put words on how amazing it all was to her friend – even though she is still embarrassed over reacting so strongly to something she knows is not real. She concludes that this is nothing for her as it is clearly a gaming gimmick, but is very glad of having learned a new experience.

"VR IS A REALLY COOL TECHNOLOGY, BUT I CANNOT SEE HOW EXACTLY WE WILL USE IT - EXCEPT FOR GAMING THAT IS."

Potential user in span 35-44

- John
- 37 years old
- Project leader
- Never tried VR, but going to try it out at an event

It is early Tuesday morning when John arrives at the office. There is going to be a kick-off event for the new project he is in, of which he will be one of the project leaders of the user interface design. Business is doing well for the consumer products company he works for, why a new line of exclusive products is going to be launched. To prototype and market these products, as well as to reach out to users and gain further attention at business fairs, it has been decided that the VR medium is going to be used. John really looks forward to be part of this outgoing project, as VR definitely is an interesting technology that is right in time - and possible what will be the future.

Personally, John has never tried VR before. Due to this, John has briefly read some articles and seen some YouTube videos about VR in his spare time, many which has pictured the immersed future ahead. Even though VR is very useful for this specific project, he is however a bit concerned about the future implications of VR. So much time is already spent with technology and wired up to social media; do we really need to be even more anti-socially immersed into technology? John reflects to his 5 year old daughter - what could she be using this for in the future and how could this affect her? Not lingering on the constant worries about his daughter, he concludes that he is glad to be part of this development of the future, as he heads for the event.

"IT IS AN INTERESTING TECHNOLOGY WITH HUGE POTENTIAL. BUT I THINK WE ALREADY SPEND SO MUCH TIME GLUED AT OUR SMARTPHONES, AND I DO NOT THINK WE NEED TO BE MORE ANTI-SOCIAL LIKE THAT."

4.4 Discussion

The surveys that were sent out treated questions explicitly regarding VR, as well as emotional questions that could be related to experience design in this medium. These emotional questions can be considered difficult to answer, due to them asking for assessments of ambient emotions in situations that not necessarily are reflected upon consciously in every day life. Similar difficulty applies the question regarding which situation of use that the potential users would be comfortable with using VR in. This is due to that it might be difficult to assess how one would feel in situations where experience is lacking or on does not reflect consciously, why a more accurate assessment of this would rather be retrieved from observation in these situations. However, asking such questions gives a hint about the direction to what people feel. Especially this is the case of VR use context and during which situations when the potential users are comfortable using VR and not, as they will bring this thoughts into the use. Furthermore, these questions gained responses which consisted of useful information, which further offered answers to the posed questions.

A part of the survey that was directed to the potential users investigated specific yet general emotional states, both in terms of pleasant and unpleasant feet experiences, but also some general emotional states. This was considered to be interesting due to that real life experience could prove as a test model of how to design VR experiences. As previously discussed, asking about ambient emotion in a general way might be difficult to answer, but could primarily be questioned in terms of actual usefulness in feet haptics. Insights about which experiences leads to certain emotions might not necessarily be included directly in a feet haptic accessory concept. However these could be highly useful when creating experience designs with such a product. Also, knowing what is appreciated to feel via the feet, and not, is important due to that it is inefficient to design a concept which is associated with negative emotions. This is the case no matter if it offers the functionality of increased immersion.

By the second survey that was sent out, half of the target group that was younger and price sensitive was primary reached, however also the older half. This was probably due to that the sample group of the survey was selected from social media and DigitasLBi's office, where these groups are overrepresented. There is also probably a bias in the answers from the DigitasLBi office, referring to more technically oriented responders than is actually representative. Similarly, the younger responders were commonly found to be students, which could be due to that it is common to be studying at this age, but could also have to do with what kind of individuals that were available via the channels of survey distribution. However, being urbans they could still be seen as representative, as different kinds of office and agency occupations are probably more common than other occupations for 35-44 year old urbans. Also, those responding to the survey were those who wanted to respond to this, which means that these responders are more likely to be those that are already a bit interested in VR, and therefore feeling entitled to respond to such a survey. By itself this means a natural self-selection of the right type of responders, as those that are not interested in VR are not interested to be using VR any time soon.

4.5 Conclusion

The previous chapter presented the results from two surveys which investigated the current users of high-end VR equipment and the potential users to come as the target group of VR widens. The current users were found to be characterized by being early technology adopters around 30 years old, who commonly had technical educations, occupations or interests – and mostly all of these combined. Their considerations regarding VR were very optimistic ones, where VR was identified as being so fantastic and holding so much potential for the future that its problematics were overlooked. However, some common problematics were found in terms of motion sickness, HMD comfort, meaningful content and pricing, but also that the illusions of VR led to accidents as e.g. trying to lean on virtual objects that are not there or tripping on the HMD cord, or difficulties with connecting to reality afterwards.

Regarding the potential users, their considerations differed from the current, where these were divided into two sub-groups; 16-24 and 25-34, to 35-44 years old. These were based on the three denominators that the younger, the higher income or more interested in gaming one is, the more likely you are to be interested in using VR. Even though the potential users also considered VR to be the technology of the future, they also questioned VR. This both in terms of usefulness and that it is just another gaming gimmick, but also worries about VR being too anti-social. Overall, the incoming users were found to be less inclined to evaluate VR in such a forgiving manner as the current users do. Relating this to the users of DigitasLBi's VR experiences, they were considered to belong to the target group of 35-44 years old. These were further found to evaluate VR more critically and not tagging along with the hype as easily, while being more comfortable with using VR experiences in a context of strangers. Lastly, when investigating what all the potential users consciously thought about some specific feet experiences, it was found that the feet are commonly used in an investigating or sacrificing manner for ground level oriented objects, which furthermore are suspicious or in some way of interest to manage.

5

User test

5.1 Purpose and Scope

The purpose of this test was to investigate how users responds to when feet haptic sensations are given to a VR experience, and what this means for the perception. To answer this, a user test was designed about haptic sensations given to a specific VR experience. The test was intended to offer insights about how this affects the total evaluation of the experience, and how realistically accurate haptic experiences actually are perceived in VR. The outcome was therefore understandings of what, why and when haptic experiences should be given to VR experiences.

5.2 Method

User test design and analysis

To provide an answer to what haptic experiences means for the VR experience, and how to use it, a virtual test site was designed and conducted (procedure in Appendix 11). The test site composition was based on the findings from the workshop of the pre-study. There it was found that different textures, sizes, shapes, hardness and temperatures held greatest technical feasibility. This virtual test site of a small obstacle course was created and experienced via Unreal Engine, which was matched and mapped against a real test site that provided haptic feedback to the experience (Figure 32). The haptic sensations that was tested was chosen as experiences that in real life are characterized by non-ambiguity. Accordingly, these elements of the test was a fire pit, a step, a pond, grass, stone floor, a board and a pile of snow, and matched with haptic input as seen in Table 9. These experiences were considered to offer specific and direct reactions to be elicited, rather than ambiguous haptic sensations which on the other hand would be more difficult to analyze. Consequently, the haptics offered were those being most accurate to the visual input without being harmful.

To understand the sensitivity of the haptic perception, the virtual test site was combined with three different types of real-world test sites that were offering haptic feedback (seen in Table 8). Part 0 meant that no haptic feedback was given to the experience except the feedback given from the actual floor, while Part 1 meant haptic feedback as realistic as possible to what was seen (seen in Figure 33). Part 2 on the other hand meant modified haptic feedback, with similar yet inaccurate haptic impressions to the visual experience. This was to further examine the sensitivity and how lite feedback that might be given yet enhancing the experience.

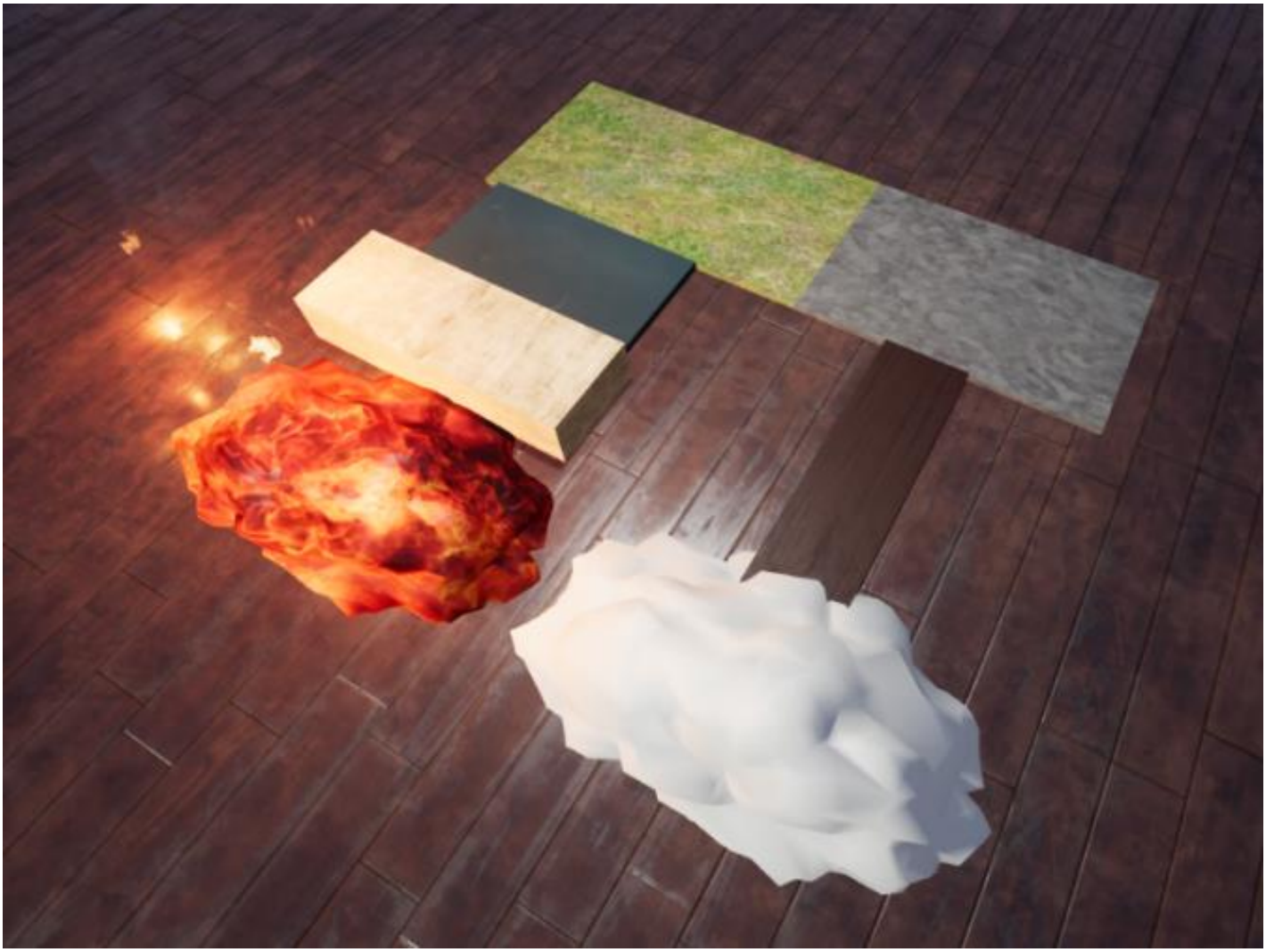


Figure 32 The test site of haptic impressions in VR.

Figure 31 The real test sites of Part 1 (left) and Part 2 (right).

Table 8 Properties and participants of each of the parts.

PART 0	PART 1	PART 2
No haptic feedback except the floor 1 participant An experienced VR user	Realistic haptic feedback 6 participants The majority are unexperienced VR users yet having tried VR. One had no experience, while another were experienced.	Modified haptic feedback 6 participants The majority are unexperienced VR users yet having tried VR. One was an experienced user.

Table 9 How passive haptics was realized for Part 1 and 2.

VISUAL INPUT	PART 1: REALISTIC FEEDBACK	PART 2: MODIFIED FEEDBACK
Fire pit	Cloth heating pads of ~45°C	Heat isolating plaid
Step	A step	A board
Pond	Tray with water	Metal sheet
Grass	Synthetic grass	Bathroom rya rug
Stone floor	Wood board with hard plastic top	The floor of the room
Board	A board	A board
Snow pile	Ice blocks wrapped in cloth	Metal sheet

Parts 1 and 2 were tested by six persons each, where the first test person was meant to be the one that the test design was evaluated against, except being one of the tests participants. For these two parts, five persons were attending both while one person always tested either Part 1 or Part 2. This arrangement was chosen to understand if and how the test persons would evaluate Part 1 against Part 2, and how this could affect the outcome. However, the arrangement was primarily chosen to measure the change and sensitivity in the haptic perception, being the primary question of investigation. The participants were selected according to being ones of the potential target group.

Part 0 differed from Part 1 and Part 2 by being a brief test with only one participant. The purpose was to give an affirming overview what the test would be perceived like when no haptic feedback is given. This was due to that it was in beforehand thought to be a rather odd experience, since the VR experience clearly visualized some sort of haptic test. Therefore, the outcome of this part was meant to give a brief overview to what the test feels like without feet haptic feedback, which normally is the current case for all VR experiences.

All the parts were induced by the participants not being allowed to in beforehand see the real-world test site of haptics, which was deemed to affect the evaluation (according to the structure seen in Appendix 5). Additionally, they would before the test fill in the first part of a brief survey regarding age and previous VR experience, as well as degree of expectations and nervousness before this test (seen in Appendix 12). Especially, the expectations and nervousness before the test were considered of interest to learn, as these could affect the performance and the evaluation in the experience. Furthermore, all the test persons were instructed to be barefoot and to start at the same place from the fire pit. The data of the test was gathered by filming all the test persons that performed the test, while these were instructed to think out loud and discuss what they experienced. After the test, the participants would fill in the second part of the survey to establish what they felt within the test as well as which haptic impressions were perceived as pleasant, realistic and their opposites. The participants were then interviewed in a semi-structured manner about their experiences and their thoughts around the whole experience to gather deeper insights.

The context of testing was set to a casual atmosphere intended to communicate being relaxed yet a serious test. This was to create surroundings where the participants would feel comfortable to express their opinions, yet perceiving the test as serious by the leader of the test having a clear order of testing. Lastly, to compile and analyze the data given from the test, the KJ-method was used (Kawakita, 1991). The content was organized according to a pattern of headlines, which treated what was actually said (seen in Figure 34), and furthermore made the content easier to analyze.

Figure 33 Resulting matrix of the KJ-method.

5.3 Result and Analysis

Experience, sensitivity and accuracy

The user tests resulted in data that offered insights about how the users react and respond when haptic feedback is given to VR experiences, as well as how sensitive and accurate they were to haptics (all data found in Appendix 13 and 14).

Performing the test without haptics in Part 0, was generally found to be a weird test, as it obviously was a haptic test of VR properties. Consequently, the test person stated that everything felt the same. Additionally, the test person mentioned feeling confident and carefree since there was nothing there. Though, the fire and step were still found scary or weird to pass through, a consequence of being hardwired behavior about how interactions with the surroundings should take place. Even so, the experience was found to differ in degree of immersion in relation to the other test parts.

From the data of the test survey of Part 1, it is seen that there were high expectations before the test (as seen in Table 10). Being in the experience, it was still exciting even though the expectations were not fully fulfilled. As for the nervousness, some of the participants assigned being nervous when given this input, while some did not. In comparison to Part 2, the excitement before testing was lower than for part one, and especially when in the experience. This was also true for the nervousness. In general this was probably due to knowing what to expect when inside the experience, but also that Part 2 was perceived as less realistic than Part 1. This is also proven by the test person whom had not tested Part 1, and further assigned higher levels of excitement and nervousness before testing.

"IT FEELS GOOD… BUT STRANGE. IT IS REAL, AND THAT IS STRANGE SINCE I KNOW THAT IT IS NOT REAL."

"THIS IS TOTALLY SICK THAT IT IS WET FOR REAL! DON'T KNOW WHAT I EXPECTED, BUT AT LEAST THAT IT WOULD BE FAKE IN SOME WAY."

What was perceived as most realistic in Part 1 differed, though those that was generally mentioned had in common being those that elicited most "wows" when first time experienced, e.g. the step and the water. However what was perceived as most unrealistic were those properties that was most difficult to simulate accurate. These ones were also those that generated a more conscious thinking about their properties, meaning fire and snow. This means that what is realistic is floating, but what is unrealistic are those impression which are actively thought about due to e.g. posing a treat. Consequently, this means that haptic insufficiency will be easier detected. Regarding Part 2, those haptics having similar properties to the real life ones were perceived as most realistic. This meant that the haptic board and the grass, being represented

"THIS DOESN'T FEEL LIKE REAL SNOW. IT DOESN'T EMBRACE MY FOOT AS IT SHOULD. BUT STILL FUN, ESPECIALLY THE CRUNCHING SOUND."

by a height wise modified board, respectively a soft bathroom mat, were found most realistic. This also seemed to have to do with previous experience from Part 1 and disappointment, but also personal associations. When it comes to being unrealistic, it was observed that the objects that generated level or hardness and active thinking about what was felt where those that were perceived as most unrealistic. Such properties were therefore trickier to get away with.

For both Part 1 and Part 2, pleasantness was those haptics which properties were related to physical sensations, but also pleasant associations, which further might be inherent or metaphorical. Same goes the other way around, though highly related to uncertainty rather than actual danger. However, for Part 2, what was found pleasant was also defined by how intriguing the experienced turned with haptics, meaning positive incongruence. The other way around, unpleasantness was when expectations were not met, especially for height levels and hardness since this led to incongruence.

Table 10 Measured data of the test survey.

EMOTION	PART 1	PART 2
Excitement	High levels of excitement before, which was not entirely met when inside the VR experience.	Less excitement than for Part 1 yet excited. Excitement decreased when testing.
Nervousness	Not very nervous before the test, with exceptions. When in the experience some was less nervous while other turned more nervous.	Low levels of nervousness, which turned even lower when testing. Test person not tested Part 1 was generally more nervous.
Realistic	The step, water and board.	The board, but also the grass.
Unrealistic	The fire pit, followed by the stone and the snow.	The snow, but also the fire and water.
Pleasant	The fire pit.	The grass.
Unpleasant	The water.	The step.

Reactions and expectations

Except offering comparisons on how the participants found the impressions and their sensitivity to these, the outcome also regarded what feet haptics means for the experience and performance. Generally it was found for all participants that offering feet haptic feedback to a VR experience would lead to problems with balance and positioning. Many of the participants further commented this, where the reason most often was said to be due to them missing their feet but also the rest of the body. When the participants discovered that haptics was given to the experience, it was also common for all to react with positive surprise, followed by a certain insecurity and requirement of time. Some participants commented this as being due to not knowing what to expect since everything could be possible now. This surprise would in time pass, as the participants would adapt around their expectations. As for those being unexperienced with VR the whole concept of VR would be a lot to take in just by the visuals, why the haptic impression would only mean another level of things to take in. Consequently, this lead to that things were missed or generally acting disorderly.

"SUDDENLY I CANNOT TRUST THAT THINGS ARE NOT THERE, THAT I JUST CAN IGNORE THEM."

"THIS WASN'T COLD, WELL, A BIT COLD THEN. IT FEELS LIKE I'M STANDING ON A TRAY."

As the surprise and "wow" regarding the haptics passed, the expectations regarding an inner consistence of the haptics were put at an unconsciously high level. If these expectations on consistence in the haptic execution were not met for all kinds of impressions, the participants turned disappointed. This incongruence with the expectations also meant that the participants were made consciously aware about what they were actually feeling, which lead to a conscious evaluation of what they were actually feeling. This could further lead them to reveal what was really felt, which took them out of the presence. This was especially seen in between Part 1 and Part 2, but also internally within these parts.

Throughout the tests, it was observed that the foot was used in a sacrificing manner before putting the whole body onto something perceived as e.g. potentially harmful as the fire pit. This confirmed what was mentioned in the surveys. However, this was not to be confused with the "walking in blind" phenomena, which was also observed. Some of the participants expressed that they perceived this as a consequence of not seeing their feet and body, which affected their ability to aim and place the feet right.

"THAT WAS DIFFICULT… [REFERRING TO AIMING WITH THE FOOT] IT WAS SCARY THAT I DID NOT SEE WHERE MY FOOT WERE. I LOST MY BALANCE, AND I AM NOT USED TO THAT."

"ONE KNOWS THAT IT IS NOT REAL, BUT ONE'S HEAD STILL THINKS "WILL IT HURT?" THEN IT FEELS REAL ANYWAY."

As previously discussed, reactions to experiences in VR takes place similarly to how these would in real life. Especially, it was observed that it is highly unnerving to do dangerous things in VR. This is something that is hardwired within us, and made the participants avoid the haptics percieved as upleasant even after experienceing these for the first time, e.g. the fire or the pond. It was howevered commented by one participant that trust to the testleaders intentions meant that the fire pit was not percieved as scary as it would have been percieved, when not knowing who had been creating the VR experience and what the intentions wouls have been. In that case, the participant would have been more reserved about testing the haptic experience. In general this implies that experiences were avoided to another extent with haptics than without, expecially when having a notion of danger to them. Similarily, it was pleasant to loiter at haptic places associated with security and familiarity, which the haptics contribute to, e.g. the grass.

"IT WAS NICER TODAY, BECAUSE TODAY IT WAS SOFT. YESTERDAY IT WAS PLASTIC, GOLF GREEN LIKE. NOW IT FELT MORE REAL, IT FELT BETTER."

During the test it was found that properties that were measureable were perceived differently between the participants. This was seen especially when the height of the board was changed between Part 1 and Part 2, where some perceived the board to be narrower, while some expressed it to be the same. The impressions given via visuals and haptics also interacted in creating new associations. For one participant this was manifested in the evaluation of the grass, in which Part 1 was perceived as being a golf course lawn, when being matched haptic wise with a fake grass mat. As for Part 2, the visual perception changed to being perceived as a mossy lawn, when the haptic impression was given by the bathroom mat.

"NOW IT TURNED VERY COLD, LIKE WHEN ONE IS WALKING ON A BATHING JETTY AFTER EXITING THE SAUNA."

"SCARCE VISUAL INPUT DOES NOT MEAN THAT MUCH, IT IS JUST WEIRD IF SOMETHING IS FELT, IT DOES NOT MEAN ANYTHING THEN."

It was also found that if the participants would perceive the visual input as scarce or unclear of what it represented, the feet haptic feedback could not make up for this no matter how accurate in its performance. The other way around, if the attention was overridden with visual input, less attention was put on evaluation what was actually felt by the feet. Furthermore, this also meant that the more attention allowed to actively think about what is felt, or any room given to people to reflect on what they are

"THIS FIRST IMPRESSION IS SO FUNNY BECAUSE IT IS WARM... THOUGH IT SHOULD BE WARMER."

perceiving, the higher demands are put on the accuracy of the feet haptic design. In addition to this it was observed that many participants wanted to establish global relations between the different haptic impression within the experience.

"I COULD JUST AS WELL BEEN SHUTTING MY EYES BECAUSE I CANNOT SEE WHERE I AM GOING. I FEEL IT MOVING BUT IT DOES NOT MOVE BELOW ME."

Regarding what types of impressions that made the greatest impact when given or not, these were found to be drastic hardness changes, shapes and rough textures that simulated height levels by interacting with the sense of proprioception. This was especially seen for the case of the step and the pile of snow. When given a haptic perception of stepping up a little bit and increasing the height, this offered a greater degree of immersion. However these haptics were quickly taken for granted. But when these properties on the other hand were taken away, this was intensely commented – especially if there where other kinds of haptics included. For the distinct hardness changes, shapes and rough textures, which further simulates height levels, this implies that they are not constantly noticed when included, but noticed when gone. But except the participants percieving it as unnerving being "inside" a virtual object, they also found it unnerving feeling a haptic impression without seeing the effect of this visually in VR. This was seen for e.g. the pond and the snow, where some said that since they felt it, they should also see it as e.g. the water rippling or footsteps in the snow.

"IT IS THE SAME THING AS FOR THE GRASS. [REFERRING TO THE SNOW PILE] IT IS NOT JUST A SURFACE, ONE IS ALSO SINKING INTO IT."

Providing feet haptics to the experience were over all commented as offering a more interesting experience, which further meant a higher degree of immersion. Some participants added that it also gave an odd experience due to being so realistic, even if they consciously knew that it was not real. For some this meant a contradiction in itself since VR is not supposed to be too realistic, and that the concept of VR in itself is a promise about being allowed to do anything without actually doing it. Two participants commented that it could be okey if experiences turned more realistic via feet haptics, but then they wanted warnings in advance about what to expect. This would also affect the context of their use, which was examplified by one user as not being suitable as e.g. an after work activity.

"I THINK VR IS A VERY EASY WAY TO TRY THINGS OUT. YOU GET 10% OF THE REAL THING WHILE BEING SAFE DURING THE WHOLE THING, WHICH THE FIRE OFFERED. THE WATER ON THE OTHER SIDE OF IT WAS ACTUALLY REAL, I WAS WET. I FEEL A BIT TRICKED, BECAUSE WASN'T FAKE, IT WAS REAL! THEN I RATHER TRY IT FOR REAL."

Implications about how interactions and expectations are formed

From the results of the tests, conclusions can be drawn about why the test persons reacted as they did. First off, people unconsciously create intrinsic rules of interaction for the virtual environment together with haptics, and consequently consistency according to these is expected. These intrinsic rules are based on uniformity in the performance of the visuals together with the haptic impression. When these rules are broken incongruence is created, which means that more time is needed and that the user turns conscious about the haptics. This active evaluation of what is felt can consequently lead to a negative evaluation, which sticks a hole in the perception of presence. But if the expectations are met according to these rules, this incongruence leads to a positive evaluation. However, such positive reactions will increasingly turn neutral as haptics are taken for granted over time. The "wow" sensations that an experience might lead to is fun the first few times, but not long time useful as an actual functionality.

5.4 Discussion

The result of this user test, together with was has been previously presented, stresses the importance of discussing actual relevance, need or usefulness of feet haptic impression for the VR experience. As earlier stated, the feet are not the most sensitive part of the body, why the existence of a feet haptic product could be questioned. As also seen, it is not expected of VR to be too realistic, which all haptics provides to, nor necessarily wanted to be for some experiences. This user expectation has commonly to do with what is perceived as technically feasible to deliver, since it has never been a functionality of VR to offer feet haptic feedback. VR has earlier thrived on that the visual immersion is possible, which has been perceived as sufficient until now. As a consequence it is reasonable to question why there would be a need of feet haptic functionality.

A need is seen since the feet differs from other body areas. They are constantly in contact with the ground, and thereby unconsciously and continuously gathering information about the context we are in. This means that a unique functionality is offered by feet haptics that more haptic wise sensitive body areas does not provide to, e.g. the hands. The feet are put at risk in another extent than other more sensitive body areas are, and if offering VR haptics generally is perceived as too realistic or too close, the case is different for the feet. Haptics given to the feet can increase the immersion, while at the same time not breaking the promise of not being real. Additionally, since the feet are less sensitive than other body areas while shaping our perceptions unconsciously, the demands of the quality and accuracy to real life haptic performance are lower than for other body areas.

If feet haptics offers an increased immersion while not turning too uncomfortably close, when is this actually useful in VR experiences? As the importance of the ground increases in the experience, the importance of providing feet haptic impressions also increases. This importance means not only if the creators has assigned the ground of the VR experience to play a part of in the functionality, but also refers to if the users evaluate the ground properties as interesting, relevant or important. Consequently, feet haptics means usefulness for experiences spanning from any training simulator functionality where the performance of the ground properties are relevant, to educational tools where the understandings created by the immersion can be increased by adding this appropriate level of immersion which feet haptics means. Similar goes for entertaining experiences, where feet haptics can be used to increase the entertaining immersion, while the insensitivity means that the realism is kept at a safe distance. Feet haptics are also of great use in experiences where the actual immersion is the main functionality, which is a common case for many current and incoming experiences. Also, as difficulties were found in staying within or remember the guardian grid while in the experience, an additional functionality of feet haptics could be found here due to the orientation of the feet. The use cases presented altogether means areas where DigitasLBi operates or could operate in the future, which furthermore implies the usefulness of feet haptics for their experiences.

The case of the testing where the majority of the participants participated in both Part 1 and Part 2, means a risk of errors in the results. This since it is possible that there were

differences in the experiences that were evaluated against each other, rather than an evaluation of how much haptics that is actually needed. But establishing an evaluation on how sensitive the perception of haptics is, is not only determined by what the participants consciously said, but also what was observed and meant. Having one participant in each of the parts being isolated to only this test offered insights about what the consequences were in the perception due to comparisons, between Part 1 and Part 2. However, the cases which obviously treated comparisons between Part 1 and 2 provided crucial insights about haptics incongruences, what this means for the VR experience and the immersion.

A main outcome from the test was that as feet haptics was introduced to the experience, the users perceived problems with balance and positioning. Many assigned this due to not seeing their feet. This stresses the importance of seeing one's body in VR, not only because it feels weird not having a body, but also because this enhances the performance. Even so, mapping the participants a body in the experience was not included in the testing, why it could be difficult to determine if the problems with balance and positioning were due to missing a body or being given haptic experiences. It is consequently possible that it is offering feet haptic experiences which could cloud the perception and performance, thereby leading to these problems. However, as problems with balance and positioning due to any kind of cognitive loading are generally not a widespread problem in real life, it is more likely that missing a body was the source to this. This implies that performing the test with a mapped body in VR could erase the problems with balance and positioning, further allowing new data to be discovered. The amount of data and insights that were elicited when not mapping a body into VR, versus the technical hassles and time needed for an exact mapping of the body into VR, implies that sufficient and succinct insights about the feet haptics could be gathered anyway. Nevertheless, mapping a body while experiencing haptics in VR is still of importance for further testing.

A similar argumentation applies to the accuracy in the haptic feedback, and the mapping between the haptic obstacle course in the real world and the one of the VR experience. During the tests, some unforeseen technical incidents were caused by the tracking of the room and headset being disrupted by reflections from widows and a mirror, further leading to the virtual room being radically tilted. In most cases, the test leader would notice this tilt, and could correct this before testing. A strategy before testing was also found to hinder this from happening. Even so, it is possible that these the tilts also could have happened on an incremental level which might have passed without notice. This means that the mapping of the real world test site and the virtual one might have been misplaced, which furthermore could have affected the participant's evaluations. Similar faults in the mapping could also have occurred as the mapping between the test sites was done manually, naturally affecting the quality and accuracy in this. However, the amounts of elicited information from the test, versus the human inability to perceive things with exact accuracy and the difficulties in establishing an exact mapping, indicates that sufficiently accurate data could be elicited anyway – even if such problems with the mapping occurred.

The experience that was tested with mapped haptics differs from the kinds of experiences that are currently offered. This is in terms of that the participants knew that this was an evaluation of how they perceived a VR experience with given feet haptics, and this further means a rather static experience in relation to other experiences. In general, VR experiences consist of more impressions and interactions that the tested experience did. This consequently means that these experiences can cloud the conscious attention from the experiences of the feet, meaning that the insensitivity to what is perceived could increase even more. As argued about earlier regarding the importance of feet haptics in relevant experiences, clouding the conscious perception with other impressions means that the demands on quality and accuracy of the feet haptics decreases. In these kinds of experiences the users will not focus that much on evaluating what is felt in the feet, which differs from the test. These differences means that the qualities held by a realistic situation of use rather could work in advance by lowering the demands on quality and accuracy, than providing new ones.

The results from this test stressed that some things are hardwired within humans to be perceived as unnerving, due to these posing a potential threat in real life. This means all things from potentially dangerous interactions, as walking through fire or jumping from a cliff, to impossible interactions of the real world, e.g. passing through a wall. VR has many times been suggested as a useful tool for cognitive treatments and unlearning behavior as e.g. phobias. An important note to this is consequently the other way around - to not accidently unlearn important unconscious behaviors after prolonged VR use of an experience including such important in real world interactions. As small of a risk as it might seem, it might not be impossible to unlearn such hardwired behaviors from VR use. The consequences could produce reckless behavior in real life interactions, for example not looking out for treats as much as one should or not avoid hitting objects with enough accuracy. Whether or not, VR experience design should avoid such risks of changing behaviors until more is known.

5.5 Conclusion

The user test presented in this chapter offer insights about how the users react and respond to VR experiences that are given feet haptics. It was found that the feet are easy to stimulate, by being easily tricked into perceiving illusions and accessing new experience levels that increases the immersion. Even though it was considered fantastic when haptic experiences was introduced to the VR experience, some users thought that a promise was broken. This broken promise referred to being able to do and experience things without doing it for real, which the haptics contradicted. Therefore, unnerving experiences were avoided and not sought after. When haptics were introduced to the experience it was also noted that the participants would perceive difficulties with balance, which was commonly referred to as a consequence of not seeing the feet. This implies that seeing one's feet in VR is not only pleasant, but also increases the performance.

As the feet are a bit insensitive, but not unimportant with regards to providing crucial information, some haptic experiences made a bigger impact than others. These were found to be distinct hardness, shapes and rough textures, which to some extent simulated height level impressions. For these, and especially in terms of height differences, the impressions were not always consciously and continuously reflected upon when given, but highly noticed when gone. When conscious evaluations emerged were found to be due to that as soon as haptics were given to the experience, the participants expected an inner consistence of the haptics to be held in relation to what is seen. In turn, the evaluation would require extra time, but also that the quality and accuracy in the design of the haptics were reflected upon. These surprises the incongruent haptics generated were sometimes interesting, but not useful in the long-term perspective. The users' expectations increased with these, which consequently lead to conscious disappointment when not matched. Therefore it is unnecessary to design highly real life accurate haptic experiences if this cannot be achieved for all VR elements of similar visual qualities. Less advanced haptics could be almost as useful for the immersion while being more easily implemented. Altogether, a conclusion of the study is that feet haptics are of use when maximized immersion is the main functionality of the experience – without making the VR experience turn too uncomfortable realistic for the user.

6

Experience design guidelines

6.1 Purpose and Scope

The following chapter compresses the insights retrieved from the studies of this project into guidelines, which are general considerations of use when designing VR experiences. Altogether, the guidelines pose a recipe for how to design VR experiences, with and without feet haptics.

6.2 Method

Compiling and arranging data into experience design guidelines

To compile the information retrieved via the studies, and condense this massive amount of data into guidelines, the KJ-method by Kawakita was used. The general guidelines were grouped into categories of what they treated, further making the content easier to apprehend. These are design communication of VR experiences that targets the potential users, designing VR experiences from a user perspective and including feet haptics into a design. Overall, these guidelines were designed to be useful when generally creating VR experiences as well as such with feet haptic experiences, which were of interest for DigitasLBi to retrieve.

6.3 Result and Analysis

General guidelines for experience design and of haptics

Initial questions to pose when designing a VR experience:

Who

… is going to use this experience and what preferences or prejudices do they have? What are the target groups specific concerns for a similar experience in real life and how can that affect the design?

What

… is the purpose with this design? Which goals are supposed to be reached and how are similar goals reached in reality?

How

… would the user interact in the experience, and expect it to respond, if it was experienced in reality? Can similar interaction patterns be used as in real life or will they mean unnecessary work for the user?

Will

… the experience hold unreal properties, and could this shift the user focus in relation to where the focus should be?

Specific questions to pose when designing feet haptics for VR experiences:

How

… can haptics provide to or affect the purpose and functionality of the experience?

How

… would the user interact and react to haptics of this experience design if these were in any similar real life experience? Would they be avoided, pass unnoticed, important or interesting?

What

… will the consequences be on the experience when the users are given haptic feedback?

What

… types of haptic feedback are already given by the fixed ground in the real room, and does this match or mismatch with what is virtually seen? Can the properties of the fixed ground be used just as well?

GUIDELINES

DIRECTING TO THE POTENTIAL USERS

Consider that the potential users of VR are not attracted by the same content as the early adopters and are critically evaluating VR experiences

Create content that is engaging for target groups beyond the technology niche. Therefore, target gender equally and beyond early adopter's interests and concerns to widen the group of potential users.

Communicate values of futurism and high tech, but also additional ones to include users of lower technology self confidence

VR benefits from communicating futurism and high tech, but should also communicate additional values to not unnecessarily exclude individuals with lower technology confidence than early adopters.

Not only be about games and technology

Expand purposes and functionalities of VR experiences out of the gaming and technology section to reach out to more potential users.

USPs are key to attract users

Do not forget the USPs of the experience, as these are essential to attract the potential users and makes them return.

Communicate what functionality and benefits that can be given now

Communicate concrete benefits and functionalities of the experience rather than ambient predictions of the future uses.

Do not feed the hype but work with what is possible to do with VR now

Work with what VR can offer now rather than further feeding the VR hype of what might be done in the future via this medium. The incoming users already expect VR to be that multifunctional tool of the future, which has been communicated until this point, and consequently expects high-end functionality.

Avoid being socially excluding as this is a worry of the potential users
The experiences should not be too socially excluding if not necessarily. This is due to that the quality VR has of shutting out the real world also is perceived with worry and unnerving by the potential users.

DESIGNING EXPERIENCES FROM A USER PERSPECTIVE

Functionality and use

Give the user a VR body
A body is not only good and appropriate to have, but also increases the performance.

Focus on delivering long-time functionality rather than a "wow"
Provide a functionality that could be long-time useful, instead of "because it is possible" or to offer wow-experiences, and similar. These experiences are not long-time useful.

Investigate potential clashes with human abilities
Always investigate how human physical and cognitive restraints relates to the functions and elicited reactions of the VR experience, and if this could mean a clash.

Not having to pass through objects
Avoid making users having to pass through elements in VR that is not possible in real life. This is unnerving and we are not used to do it - and should not unlearn to do.

Investigate implications of prolonged use
Regarding prolonged, always investigate what consequences long time uses could mean for the human physics and cognition.

Do not shut out the real world if unnecessary
Do not shut down the connection to the real world too much, as this can mean dangers, in terms of collisions or making experiences too realistic and consequently unnerving.

Children should not use VR until more is known
Avoid directing experiences to children, since children should not use VR until more is known about its consequences.

Predict and avoid unplanned illusions

Avoid elements and cues in experiences that might have "illusion qualities", e.g. over-communicating that something is there when it is not, and vice versa.

Scary or hurting experiences generates uncontrollable reactions

Avoid scaring or real life hurting experiences as it generates uncontrollable reactions and reflexes, which furthermore affects performance and accuracy.

Do not force unnerving or dangerous experiences onto the user

If not having a clearly motivated purpose and use, avoid forcing experiences on the user that might be interpreted as unnerving or dangerous in real life. If including potentially unnerving elements, always investigate what consequences these could mean for the user before implementing them.

Different screen technologies with own communication styles used daily

Since the potential users daily uses various screen technologies, having their own style of communication, they are used to balancing several communication styles. This means both that they could be open to learning the new style VR means, and that this could affect and slow down their learning process.

Cognition and emotion

It is impossible to be aware of everything

We cannot know everything and big changes can occur without these being noticed. This cognitive restraint might be used to reduce the workload of creating the experience.

Avoid unnecessary cognitive load, especially for first-time users

Do not maximize the experience with excessive cognitive load when directing first time users. Generally, cognitively overwhelming experiences should be avoided if this cannot be functionally motivated.

Make use of positive emotional associations

Include elements of safety, guidance or affirmation to increase braveness and performance in VR. This could be e.g. a pet, compliments or elements associated with home and family.

Negative emotional associations are time limits and unfamiliarity
Time limits and task overload, as well as stepping outside comfort zones and new social situations, characterizes situations in real life that elicit stress and unconfidence. This also applies to experiences in VR and should be considered if unconfidence and stress is not sought after in the experience.

Do not threat or hurt elements close at heart to the user
VR elements assigned with closeness to the users should not be exposed to threats, e.g. the body, homely or caring associated elements. Such interactions are associated with being scary and threating in real life, which further applies to VR.

Manipulating perception of self and social situations are a grey zone
Avoid heavy manipulations of self-perception and social hallucinations before more is known in this area.

DESIGNING FEET HAPTICS FOR VR

Functionality and use

VR holds a promise of doing without doing for real
It is very common among users to perceive the medium of VR to hold a promise of doing things without actually doing them in real life. Consequently, haptics are needed for the experience, but should not necessarily hold real life accuracy - especially for unnerving elements.

The right impressions rather than all impressions
When offering haptics it is more important to assign properties to the right elements within the experience, rather than assign haptics to all elements.

Feet are unconsciously important and less sensitive, which is useful for the immersion
Due to that the feet are not consciously sensitive, yet unconsciously gathering information constantly, the feet hold a unique functionality of maximizing the immersion without breaking the promise of turning too real.

Match what is felt in the haptics with the visual input
The visuals should match what is felt. If e.g. an impression is felt, an impression must also be seen.

Feet haptics are useful when presence and immersion is the main functionality

Offer feet haptics when maximized immersion is the key function of the experience, without making the experience too uncomfortably real. Specifically this is referring to:

- Educational or training experiences, where learning insights of "being there" is the purpose of the experience, e.g. deepened situational understanding or empathy.
- Entertainment experiences, where the immersion into the entertaining experience is the motivation to making it a VR experience, e.g. VR movies and games.
- Help out with crucial functionalities of VR which could just as well be controlled by the feet, e.g. stay within the guardian grid.

Functionality needed when important to the experience or a case where feet are commonly used for investigation

Offer functionality to the feet when ground elements that are important to the experience, especially when these are suspicious, a bit risky, potentially icky or generally needed to be explored, which are the cases when feet are used for investigation.

Give haptics when this input would be important in a resembling real experience

Offer haptics when such properties could be sought after by the user in any similar real world experience. This means when the user would expect, want or need feet haptic feedback in such experiences.

Realistic haptics is only needed when relying on this function or element

Give precise and real world accurate feet haptics when the experience fundamentally relies on the interaction with these elements. This not only due to that haptics increases the immersion, but also since important elements for the experience will generate conscious evaluations.

Do not use haptics in unnerving, scary or unpleasant experiences

Avoid assigning haptics to VR experiences or elements that could be perceived as unnerving, scary or very unpleasant. This is due to that such impressions are generally not desired and will consequently be avoided.

Many are uncomfortable with being touched

Consider that it is very common to not be comfortable with being touched by strangers or objects, which also applies to VR experiences. The appropriateness has to do with the context, quality, duration, intensity and circumstances, which should be considered when applying externally approaching haptics.

Haptics cannot make up for scarce visual input

There is no point in assigning haptics to VR elements that are visually scarce. Haptics cannot make up for such inconsistencies, and will furthermore be confusing to the user.

Cognition and emotion

The user expects inner consistency in the haptic design

As soon as the users notice that haptic are given, they will expect an inner consistency in between all haptic elements. This refers to that all haptics are executed in a similar fashion, and also that elements of similar visual qualities holds similar degree of haptics.

Not all elements are consciously evaluated while still enhancing the experience

Make use of that not all properties or elements are consciously evaluated via the feet, while still enhancing the experience. This means that inconsistencies in haptic execution can be easily overridden with visuals if assigned more attention by the user.

Haptic inconsistencies generates conscious evaluation, which might be negative

Big inconsistencies to what is expected to be felt will generate positive or negative surprises, which will trigger a conscious evaluation. This means that inconsistencies in the haptic execution might be noted, but also irritation in the long term since irrelevant elements pokes the attention.

Avoid haptics to experiences that cognitively are heavyily loaded

VR experiences with heavy cognitive load should not make use of haptics that are very detailed or holds real world accuracy.

The visual input easily overrides the haptic input

Do not use intriguing or intense visuals when conscious attention is supposed to be put on what is felt haptic wise, since this will override the attention from what is felt.

Haptics emotionally associated with pleasantness and trust makes the user relax and return to this area

Smooth, soft and kindly associated haptic properties are perceived as pleasant and trustful, and are often returned to when given. Due to the pleasantness of these properties, they might be used to elicit a calming and relaxing atmosphere.

Emotionally unnerving and unpleasantly associated haptics will be avoided

Dirty, crumbly, wet, tickling, sticky or threat associated haptic properties are perceived as unpleasant and unnerving. These are unwanted and avoided, but could potentially be used if such reactions can be motivated.

Do not let the user unveil how the haptics has been implemented

If possible, try to avoid letting the user unveil and discover how the haptics have been realized technically, as this takes the user out of the immersion into the VR experience.

7

Concept development

7.1 Purpose and Scope

In the following chapter a design concept is presented, which illustrates how the insights delivered via the studies of this project can be used in VR product development to develop a feet haptic VR accessory. The presented requirement specification of the product design offers specific considerations regarding the concept development of a feet haptic VR accessory. Even though these are considering a feet haptic product, they might also be applicable for general haptic design of other body areas. The outcome of this chapter is consequently a requirement specification, concept evaluations and the final visualizations.

7.2 Method

Compiling and arranging data into a requirement specification

With a similar methodology to when creating the guidelines, the KJ-method by Kawakita was used to compile and condense the results into a requirement specification. To make the content easier to apprehend, these specific requirements were grouped into categories of what they treated, being feet haptic sensations, functionality, communication and semantics, manufacturing cost and sustainability. The resulting requirement specification, together with the experience design guidelines, meant important factors to consider when designing the feet haptic VR accessory.

Idea generation

The initial workshop, that served to evaluate technical feasibility of product designs that could offer haptic input in VR experiences, generated a wide span of idea cues that also were of further use in the concept development. To develop the ideas that were of relevance, the used methods were brain writing and drawing, and HowTo's as described by van Boejien et. al. The outcome was forms of possible concept paths to take, which were evaluated regarding which to concentrate further work upon. The chosen concept ideas was iterated again in ideation loops to develop the functionality further.

Concept path evaluation matrixes

The concept paths ideas of different feet haptic VR accessories to further continue with, were evaluated via various matrixes. These matrixes served the purpose to give an outlook over the qualities held by the concept ideas and evaluate these approximately to each other. The used measures were such perceived as relevant for further concept development, being technical complexity, flexibility, value, immersion, sustainability and feasibility, where feasibility was general as well as for DigitasLBi. The results offered a foundation of choice for which concept idea to take on for further development. Here the posed measures of evaluation are presented:

- Technical complexity, versus flexibility in amount of given feet haptic impressions
- Usefulness via the amount of given feet haptic impressions, versus feasibility
- Level of offered immersion, versus feasibility (from the perspective of DigitasLBi)
- Level of offered immersion, versus sustainability
- Delivered value

Evaluation of material properties

As motivated later on, the chosen concept path's major functionality were based on specific material compositions, why an evaluation of material properties was conducted by a breakdown of what material functions to be offered. Which material properties this breakdown considered was those haptic features which via the study was found to provide the most to the experience. Lastly, relevant materials to realize these concept materials of were based on a table compiling materials properties. In an estimating manner, this matrix evaluated different materials in terms of functionality, cost and sustainability, to further base a decision upon which materials to go for.

Concept visualization

The final design of the concept of a feet haptic VR accessory was visualized, to provide an overview of what this concept could look like. This was consequently done via visual representations and pictograms, rendered via various CAD softwares and Photoshop. In addition to this two expression boards, or collage as described by Boejien et. al, were used to present various qualities held by the concept.

7.3 Result and Analysis

Requirement specification

REQUIREMENTS		
DEMAND The concept should offer/be/hold/apply to...	**GRADING**	**QUALITY**
PROPERTIES OF FEET HAPTIC SENSATIONS		
Offer the out-ward orientated simulations of distinct hardness, rough texture and shape Due to eliciting most level immersion as well as building up to the sense of proprioception, these haptic properties are those useful for an increased immersion from a user perspective.	Demand	Objective
Preferably use passive haptics to hold greatest technical feasibility The static property of passive haptics means the lowest hanging technical feasibility in relation to haptic impressions that are flexible as the user moves within the experience.	Recommendation	Objective
Hold inner consistency The haptic design enables an inner consistency to be held for all given feet haptic sensations. This consistency refers to that the haptics experienced degree of intensity and quality in execution is perceived similarly by the user, for all the types of offered haptic impressions.	Demand	Subjective
General and ambient rather than specific and accurate haptic sensations Do not focus on giving the most exact and realistic haptic impression, as this puts expectations on an level that is difficult to over all meet.	Wish	Subjective

Assign the user virtual feet and reflect the haptic interactions in the visuals Giving the user feet, and reflecting the user's interactions with and imprints on haptic properties of the corresponding visual elements, increases the immersion and usability.	Recommendation	Objective
If giving specific and real world accurate haptic sensations these must be alerted to the user If offering haptics to the experience that is exact and realistic to those similar to the real world, the user must be alerted or given affordance about this. This applies to when: • All elements of the experience holds realistic haptic experiences • One or few single elements with high functional importance to the experience are given an extra experienced degree of intensity and quality in haptic execution, in relation to the other elements of the experience	Recommendation	Subjective
FUNCTIONAILITY		
Be of use in business marketing activities To be applicable in the activities of DigitasLBi, the concept should be developed for professional uses, however with users of the potential target group of the incoming VR users.	Demand	Objective
High-end VR The concept regards primarily experiences given by high-end VR products.	Demand	Objective
Applicable to several experiences To hold future relevance the given haptic properties should be useful for several likely cases of experiences that DigitasLBi might design for their future customers.	Demand	Objective

Used by many users with short time in-between Due to being used for professional purposes and events, the concept should support being used by many different users and within a short time in-between these.	Demand	Objective
Easy to use The concept should be easy to use for everyone, meaning un-complex functionality and use.	Demand	Subjective
Easy to exit The concept should be easy to exit in relation to the virtual experience given by the VR headset.	Demand	Subjective
Non-permanent location To be possible to transport between geographic locations, the concept should preferably not be a permanent installation.	Wish	Objective
Not add to the accidental collisions Since users have difficulties with detecting the guardian grid and real objects, the concept cannot contribute further to such difficulties.	Wish	Objective
Stand-alone product Not depend on other products to function, except for the basic VR equipment.	Demand	Objective
COMMUNICATION AND SEMANTICS		
Elicit trust among users Since haptics to VR generates insecurity, the concept should make use of cues inducing trust that matches the actual level of real world security.	Recommendation	Subjective

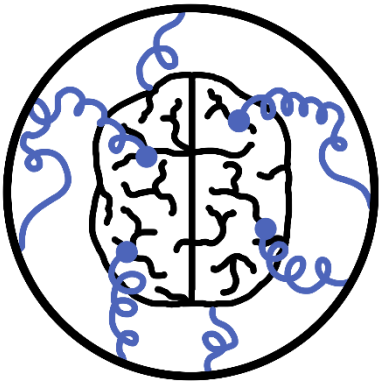
Not fuel unrealistic expectations To avoid disappointment, the concept should not fuel unrealistic expectations. This generally refers to not over-exaggerate what functionality or experience that might be given since the target group already has very high expectations.	Recommendation	Objective
Matching but inviting semantic cues The visual design should match the current semantics cues used by VR, while at the same time appeal to the new target group of potential users.	Recommendation	Subjective
MANUFACTURING COST		
Lower estimated manufacturing cost than the price of the basic VR equipment The estimated manufacturing cost of the concept should be lower than the price of the VR equipment, due to being an accessory that relies on these.	Demand	Objective
Most enhanced experience in relation to estimated manufacturing cost To compete with other VR product accessories, the concept should offer more functionality, in terms of enhanced experiences, in relation to its estimated manufacturing costs. This means more functionality per invested currency unit than other VR product accessories	Wish	Objective
SUSTAINABILITY		
Not be harmful to humans From the perspective of what is known about harmfulness of VR, the concept must aim to not include haptics that could inflict physical, psychological and social pain to users of VR.	Demand	Objective

Fit into the circular loop The concept must support a circular system by either being recyclable, reusable or biodegradable.	Demand	Objective
Reduce impact of critical parts If including critical parts, these should be able to handle separately at end-of-life, to further recycle and/or reuse these.	Wish	Objective

Pre-concept design choices

Evaluation of concept ideas

The results from the workshop, found in Appendix 5, were used and further condensed into six concept ideas, deemed to be more or less reasonable to create. Following, these are briefly presented:

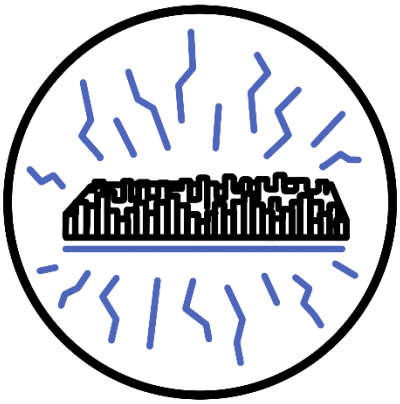


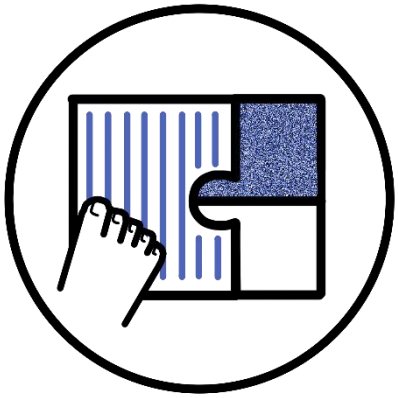
Brain and nerve system modifier

A highly technical product, which in some way interferes with brain and nerve activity to simulate somesthetic impressions. All haptic experiences can therefore be simulated via such functionality. The product is synchronized with what is experienced in VR, and adapts accordingly.

High fidelity mat

A mat with integrated technology, which holds the possibility to adapt to the impressions simulated in VR. It consequently also adapts to how the user moves within the experience. This means an advanced technical solution that can simulate a wide range of haptic experiences rather accurately to what is seen.



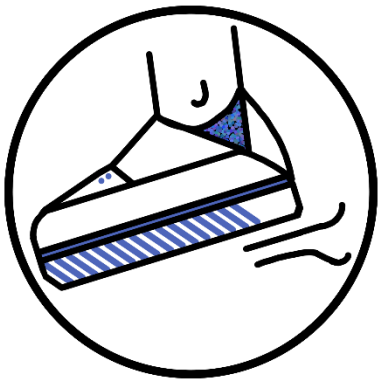


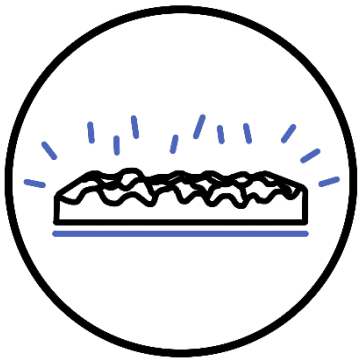
Lego mat

A mat of lower fidelity, consisting of different elements mounted together to replicate and map the haptics that should be given by the virtual experience. The elements might further be different passive haptics combined with having technology integrated, depending on what is simulated. This means that many properties can be simulated, however related to what is seen the real world accuracy of what is felt could differ, why partly depending on illusion qualities.

Haptic shoes

A shoe making use of vibrations, hardness and temperature changes to simulate and trick the user into perceiving different haptic properties. The shoe is connected to the VR equipment and adapts according to how the users moves over the virtual ground.



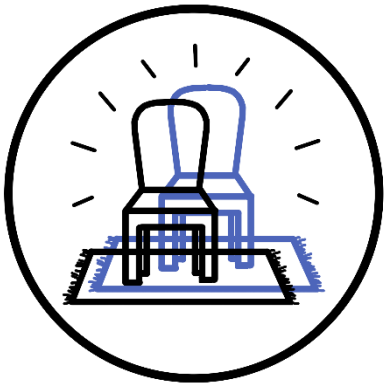


Low fidelity mat

A mat that makes use of passive haptics via various material mat properties, that in an ambient way mimics what is walked upon by making use of illusion qualities and visual dominance. This mat holds permanent qualities, which does not change as the user moves over it. Therefore, the ambient qualities does not replicate exact impressions, why it unconsciously enhances the experience.

Obstacle course

Via exactly mapped passive haptics what is seen within a specific experience is replicated, why this is a solution for a specific experience. Consequently, what is felt holds big accuracy to what is seen, but this depends on that what should be felt can be mimicked by real world objects, why illusion qualities are integrated for those.



To determine which concept to take on for further concept development, these concept ideas was further evaluated as seen in the following matrixes (Figures 35-38). In these matrixes the concepts are approximately evaluated to each other according to the chosen measures.

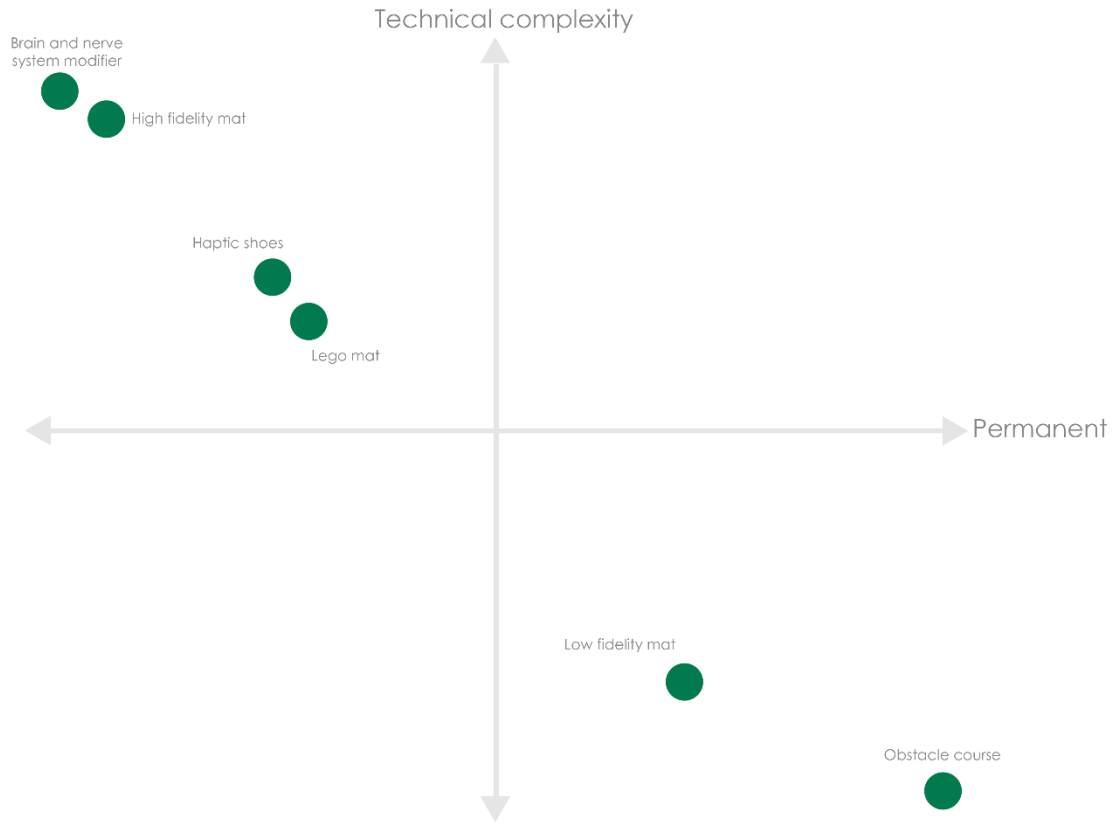


Figure 34 Technical complexity, versus flexibility in amount of given feet haptic impressions.

Figure 35 Usefulness via the amount of given feet haptic impressions, versus feasibility.

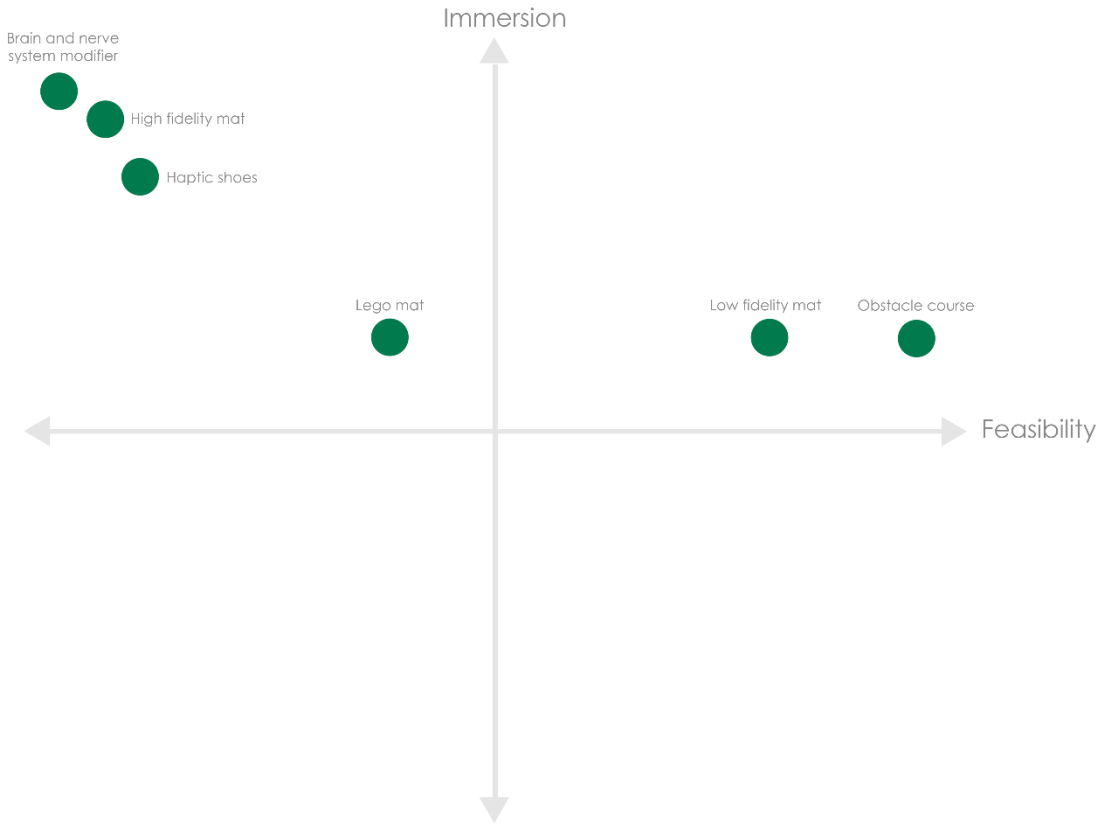


Figure 36 Level of offered immersion, versus feasibility (from the perspective of DigitasLBi).

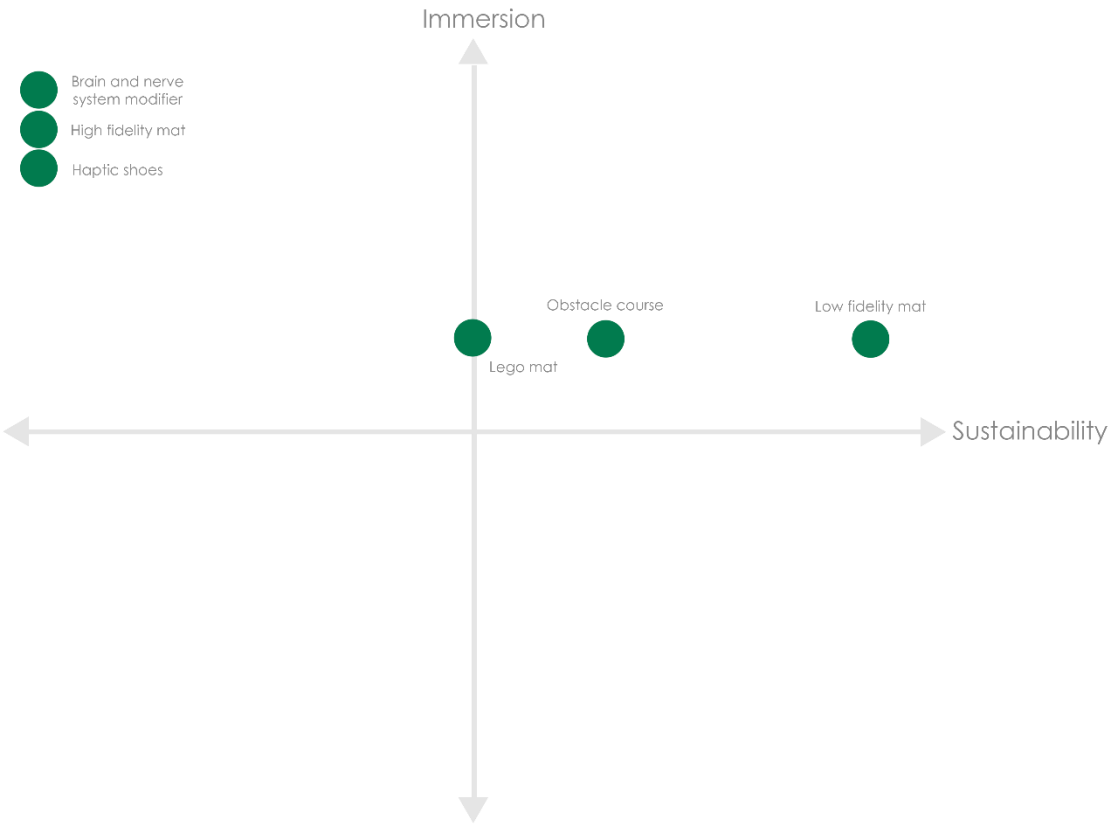


Figure 37 Level of offered immersion, versus sustainability.

The concept ideas of a brain and nerve system modifier, high fidelity mat and haptic shoes can be seen to offer a rather maximized immersion, due to their technological complexity offering possibilities to hold realistic accuracy to what is seen (Figure 37). Similarly, this means flexibility in amount of given impressions, and consequently implementations in several use areas (Figure 35 and 36). However, the degree of usefulness and immersion does not change linearly with the feasibility of the concept (Figure 36 and 37). With lower technical complexity from not including technology, the sustainability is also increasing, while lower usefulness over several use areas means a one-time product, and therefore decreased sustainability (Figure 38). With a lower technical complexity within the concept, the feasibility for DigitasLBi increases, as they are not a company characterized by manufacturing physical products. This means that the concepts of the low fidelity mat and obstacle course provides to the immersion while being most feasible in the activities of DigitasLBi. Of these two, the low fidelity mat is the most sustainable choice since it is applicable in several use areas. The concept of the Lego mat however proves to be irrelevant, as it offers similar qualities of immersion and usefulness to the concepts of lower feasibility and higher sustainability, while holding bigger technical complexity. As for the haptic shoe, it is not a product that supports quick and easy access between many users within a short time, except from it holding high technical complexity and thereby unfeasibility and unsustainability. Having these measures in mind, the relevant concept ideas from the perspective of maximizing the immersion are either those of biggest or lowest technical complexity.

From these evaluations, an approximate conclusion can be drawn regarding delivered value for DigitasLBi, seen in Figure 39. This estimation of value of the concepts is based upon the conclusion that the value increases with what is feasible to make use of for DigitasLBi and estimated degree of usefulness in several future use areas – except offering increased immersion. Consequently, the low fidelity mat holds the greatest value of these concepts, except being a feasible, useful and sustainable, why this concept idea was considered most relevant to take on for further concept development in this project.

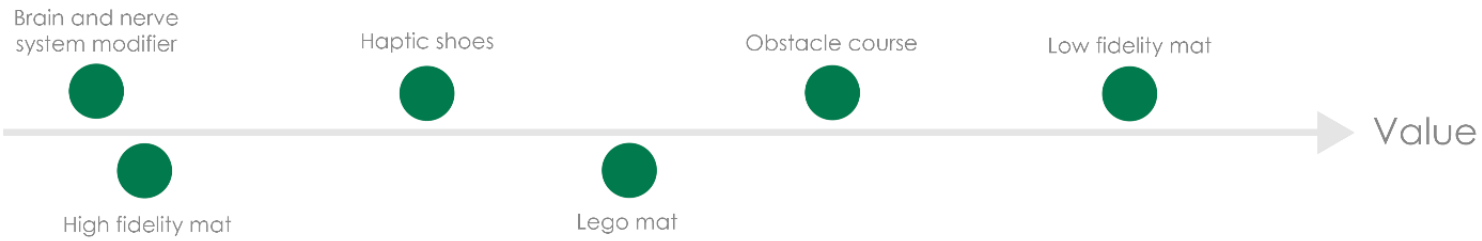


Figure 38 Estimation of the offered value for the activities of DigitasLBi.

Evaluation of material properties

As the chosen concept was based upon different mats, that via different passive haptic properties enhanced the experience, an estimation was done regarding what properties to offer. Since the test found that the properties that made the greatest impact on the

users' experience were rough textures, shapes and distinct variances in hardness, also giving impressions of level differences, the breakdown into material functions was done according to these. As presented in Table 11, what these properties mean in terms of material properties refers to having topology and hardness, balanced against corresponding qualities that should be held, i.e. the functions. As the feet are less sensitive, these qualities were chosen to be extremes, e.g. rough or smooth, since small variances of these will not be consciously noted. Additionally, materials that mimics specific ground properties were avoided, even though some common ground materials are easily realized. This had to do with the fact that the users will expect an inner consistency within the execution of all haptics, and that incongruity activates a conscious evaluation, further leading to the users unveiling the immersion. Consequently, ambient and concise material properties were evaluated as relevant, to further play on the visual dominance in what is perceived.

Table 11 Material properties and function of the concept.

SURFACE ROUGHNESS I.E. SMALL TOPOLOGY	SURFACE IRREGULARITY I.E. BIG TOPOLOGY	MATERIAL COMPLIANCE I.E. HARDNESS
Rough	Big bumpiness	Very soft
Smooth	Little bumpiness	Soft
		Hard

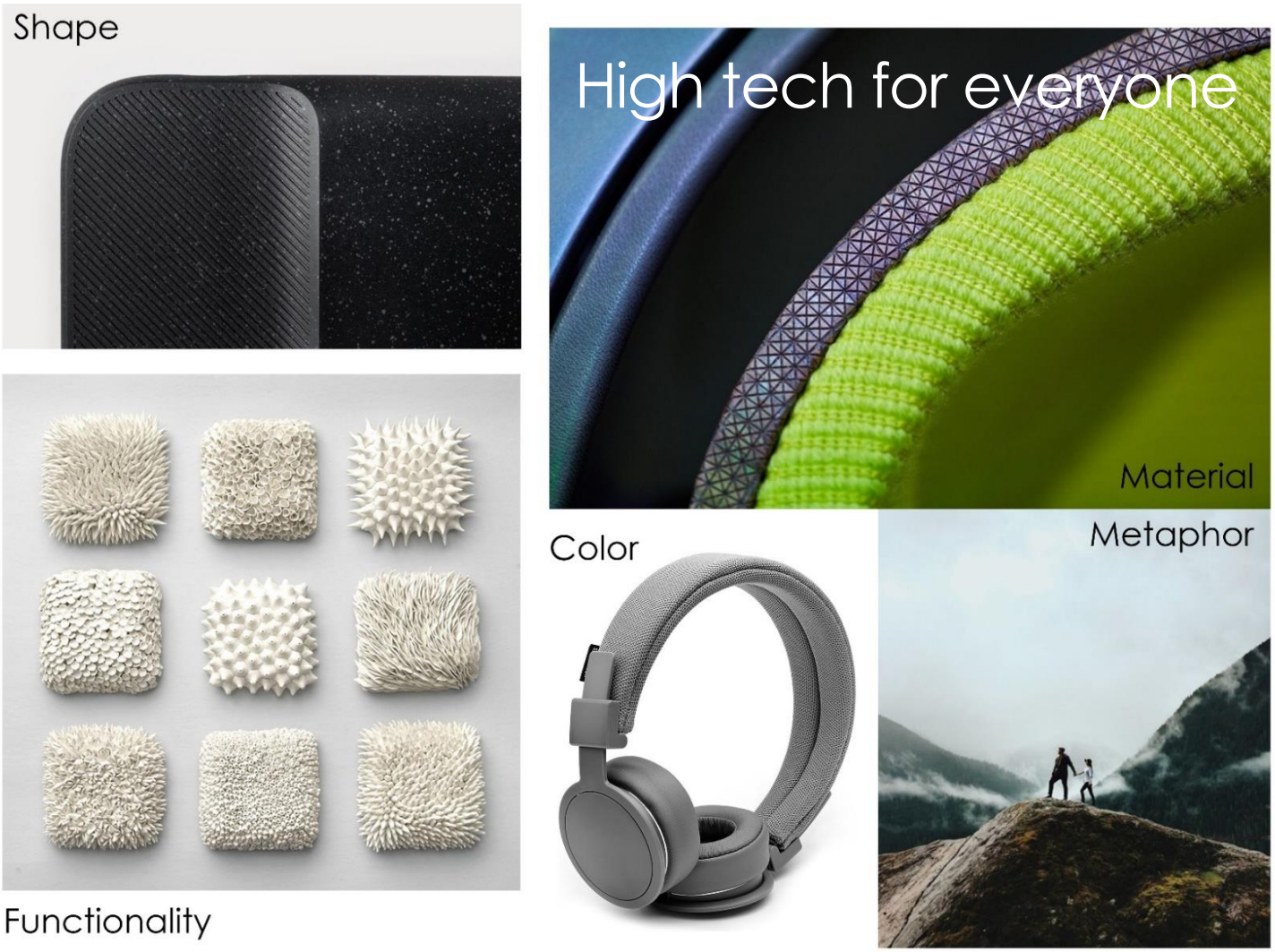
As the properties to be held by the material mats unfold, what materials to realize these in was important to evaluate. Materials that could be relevant are presented in Table 12. Here a brief estimation is presented of what these materials could mean, in terms of manufacturing mats that holds the previous properties, as well as factors of cost and sustainability. Plastics and rubber holds durability and are versatile, in combination with that they are reasonable to create many of these mats from. Additionally, some types of plastics called thermoplastics are recyclable, and therefore only holds about 65 – 85 % of the cost of virgin raw material (Sabel, 2013), i.e. the common and versatile plastic PE. Consequently, PE could be relevant to make these mats from. Cloth and fibers holds soft and versatile functionalities which can be made of plastics as well as natural fibers. Such materials are also relevant when making these kinds of mats. To offer an example, an available product being a soft PE cloth mat product, made of virgin raw material, holds an estimated cost of $3 per m2 (Leif Arvidsson AB, 2017). A concept primarily based on such materials, which is possible to make from recycled plastics and does not include any technology, means a cheap and sustainable product.

Table 12 Evaluation of materials to manufacture the concept from.

PLASTIC AND RUBBER	PAPER
Durable and versatile Relatively easy to manufacture these specific mats from Cheap however depending on which type chosen Thermoplastics are recyclable	Crisp but not durable Easy to manufacture, but difficult to make all these specific mats from Cheap Recyclable
CLOTH AND FIBERS	**METAL**
Soft and versatile Easy to make mats of, but not necessary efficient to make all of these mats from Cheap, but likely more expensive than other due to holding several levels of manufacturing Possibility to recycle depends on material	Hard, heavy, versatile and durable Difficult to make mats from, however could be done for hard mat Expensive Recyclable but generally a resource of scarcer qualities
GLASS AND STONE	**WOOD**
Hard, heavy and brittle Difficult to make mats from, however could be done for hard mat Expensive Glass is recyclable, stone reusable or degradable	Hard but unpredictable Difficult to make mats from, however could be done for hard mat Cheap however depending on which type chosen Difficult to recycle, but can be degradable

Expression board

To present the qualities of the concept, the expression board seen below is used. Overall, it describes the sought after expression of the concept design, in terms of shape, material, functionality, color and metaphor, in order to reach the communicated term "High tech for everyone". This expression board differs in relation to the expression board put together to describe the expression of the design in current VR products, found in Appendix 15. As previously mentioned, current VR products hold very dark and technical semantics, communicating gaming or a future which might feel very distant to the humans of today. This might be hard to relate to if not explicitly perceiving oneself like a gamer or a citizen of the future. Altogether, the expressions of the current VR equipment can be summarized into "High tech for the future urbans". Even though this communication has been very successful previously in creating interest of VR, another type of communication is suggested to reach out to the potential users and establish a common use of the technology, while still fitting in among the current products. To do this, the expression "High tech for everyone" should be communicated.



Shape

By integrating soft and round shapes, friendlier and more familiar shape is created.

Functionality

To create the functionality of making use of various mats to create passive haptics, various ambient and in-specific structure changes are used.

Material

The material is part of the solution, but changes in material structures from sleek to holding a structure is used to create a living expression. As a part of such imperfections, a more down to earth notion can be communicated, while still communicating the hopeful cues of an imminent future improved by technology.

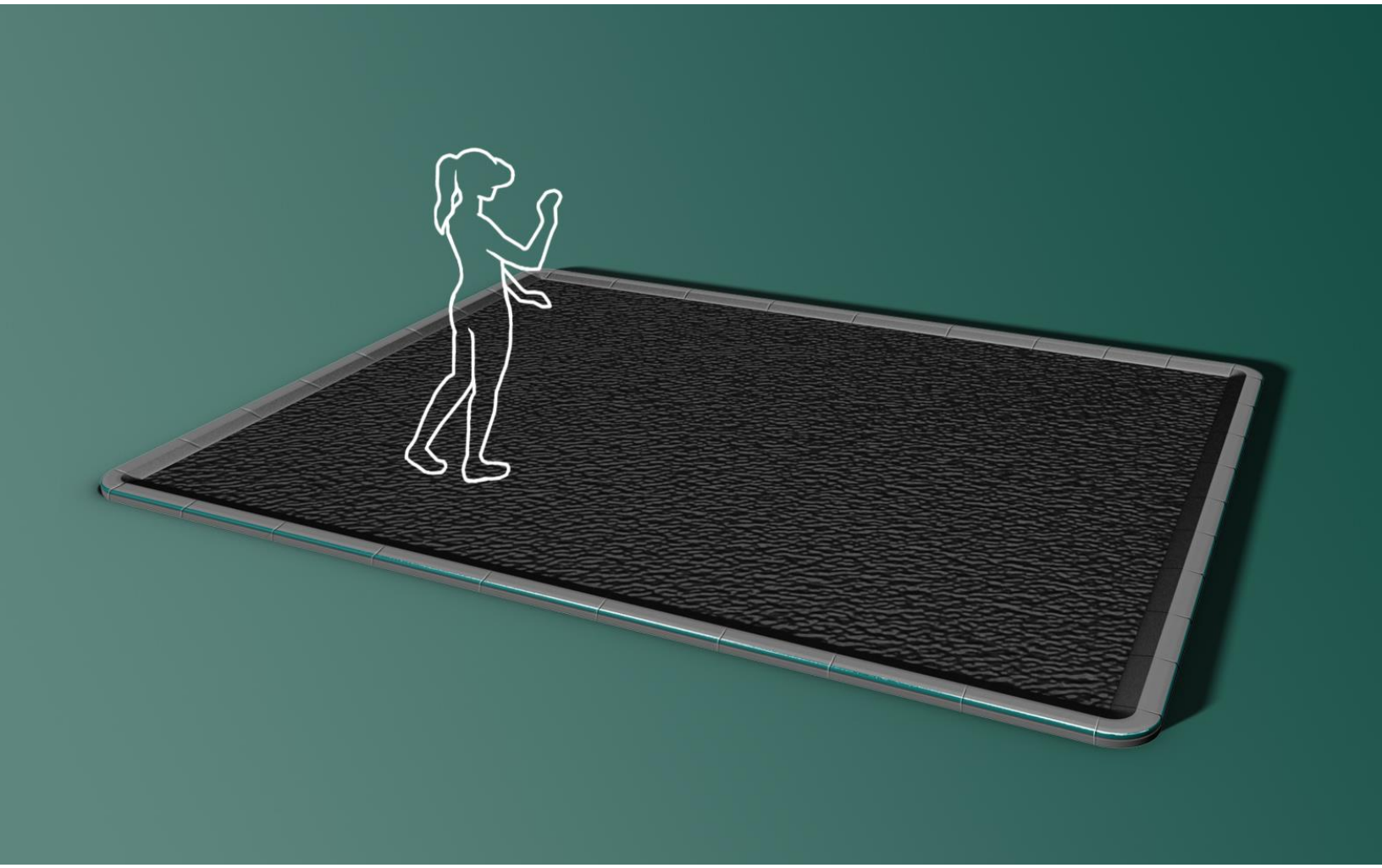
Color

To make use of cues further communicating down to earth while still being futuristically hopeful, lighter color alterations are used, together with accentuating colors. To fit in among the current VR products, dark colors alterations are also used.

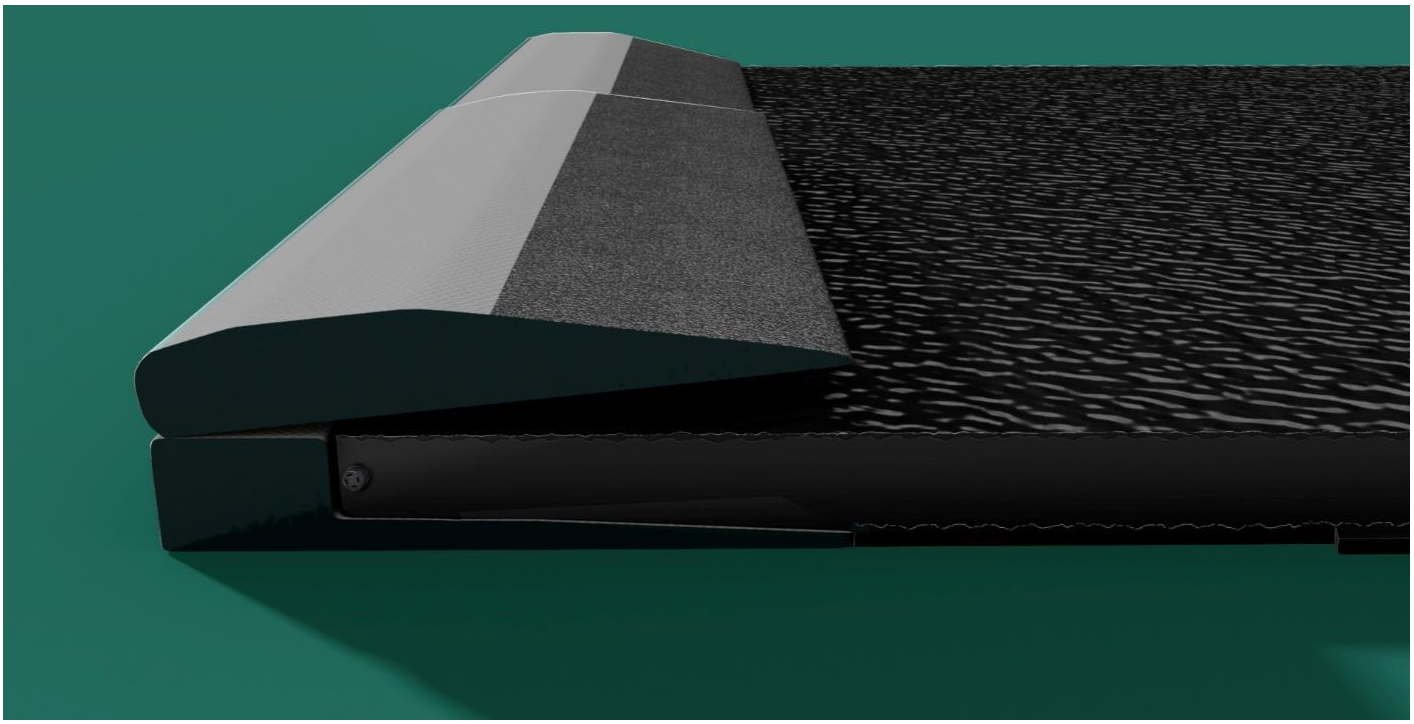
Metaphor

To relate the product to the user and disprove their worries about VR, the metaphor elicited by the design should be cue of nature, safety and being together. This due to that the potential users interests were commonly oriented around nature and health, while the cue of being together and safety is important since many are worried about the anti-social qualities an immersed future could mean. Additionally, this metaphor is highly useful when generally creating VR experiences that should reach the potential users.

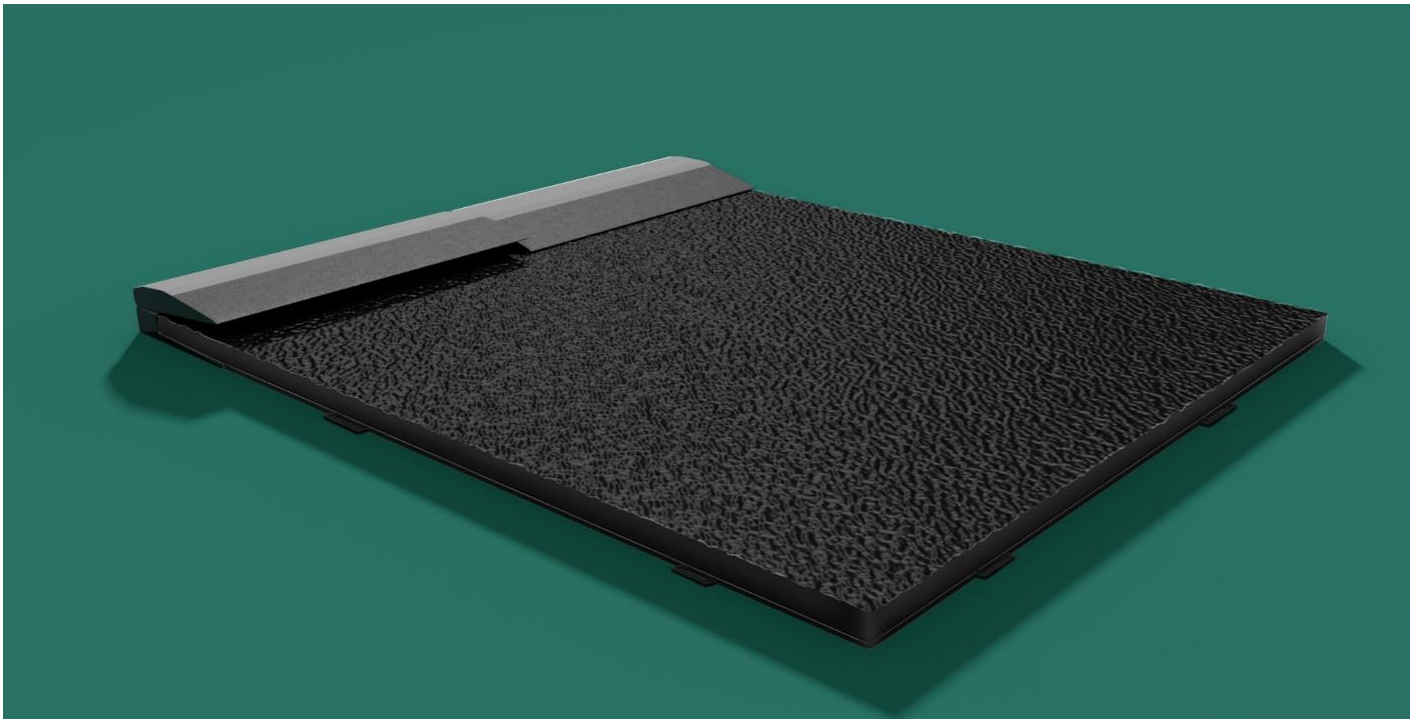
Final concept design: The VR mat



The final concept design of a feet haptic VR accessory is the VR mat, which uses different combinations of mat layers to offer passive haptics to the experience. By using ambient and in-specific haptic impressions, a deepened immersion into the experience can be achieved without the experience turning too uncomfortably realistic to the user. This means that this accessory offers functionality when the experience relies on enhancing the presence and immersion, which is the case for e.g. educating, training or entertaining experiences.

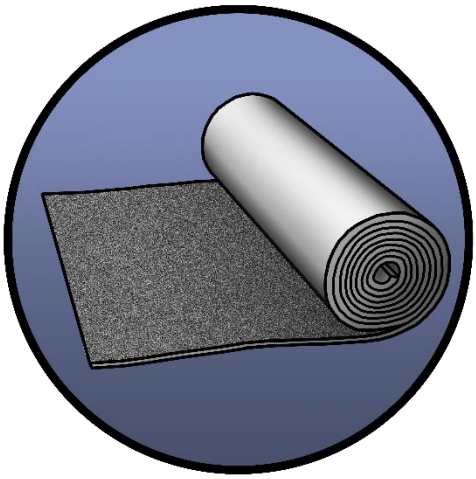


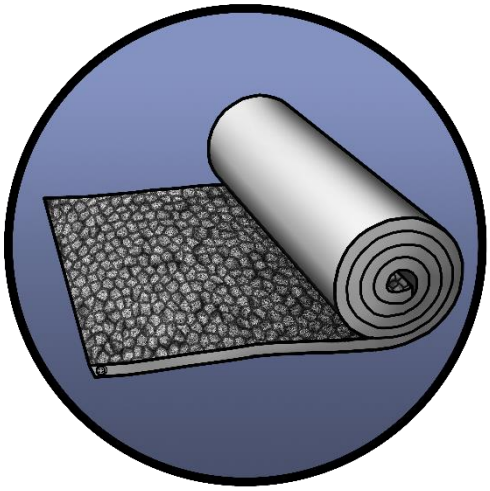
The main functionality of the mat concept is making use of different material properties, which in various layer combinations generate different impressions, seen above. This is offered via three types of mats, each having its own functionality of haptic stimuli on each side of the mat. The mat layers are hence presented, from the mat commonly placed at top to bottom.



Roughness layer

This thin layer offers two types of roughness to the surface in terms of being rugged on one side and smooth on the other side. Being a flexible mat, it can be folded or rolled up to make transportation easier.



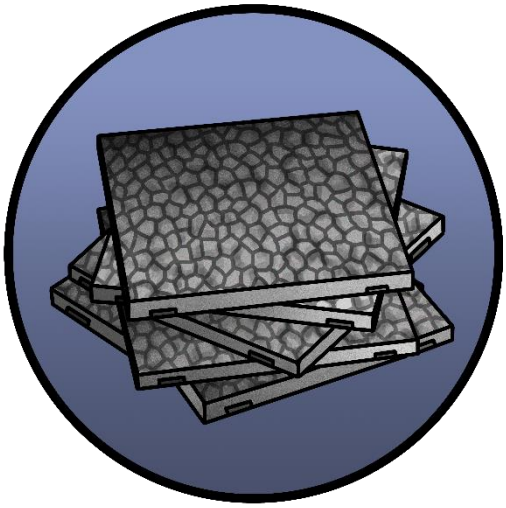


Softness layer

The layer of softness is a thicker layer that offers softness to the mat. As this layer hold a self-inflating functionality, two different degrees of softness might be received. In addition to this, the layer holds smoothness on one side, and two types of irregularities on the other one. The irregularities are retrieved depending on if the layer is inflated or not, while being deflated a bigger bumpiness is retrieved than when inflated. Since it is soft, it can be folded or rolled up when transported.

Hardness layer

The layer of hardness is a stiff layer that consists of tiles, which makes transportation handling easier. When attached to each other the tiles creates a hard surface. In addition, one side of the mat is bumpy, while the other one is smooth.

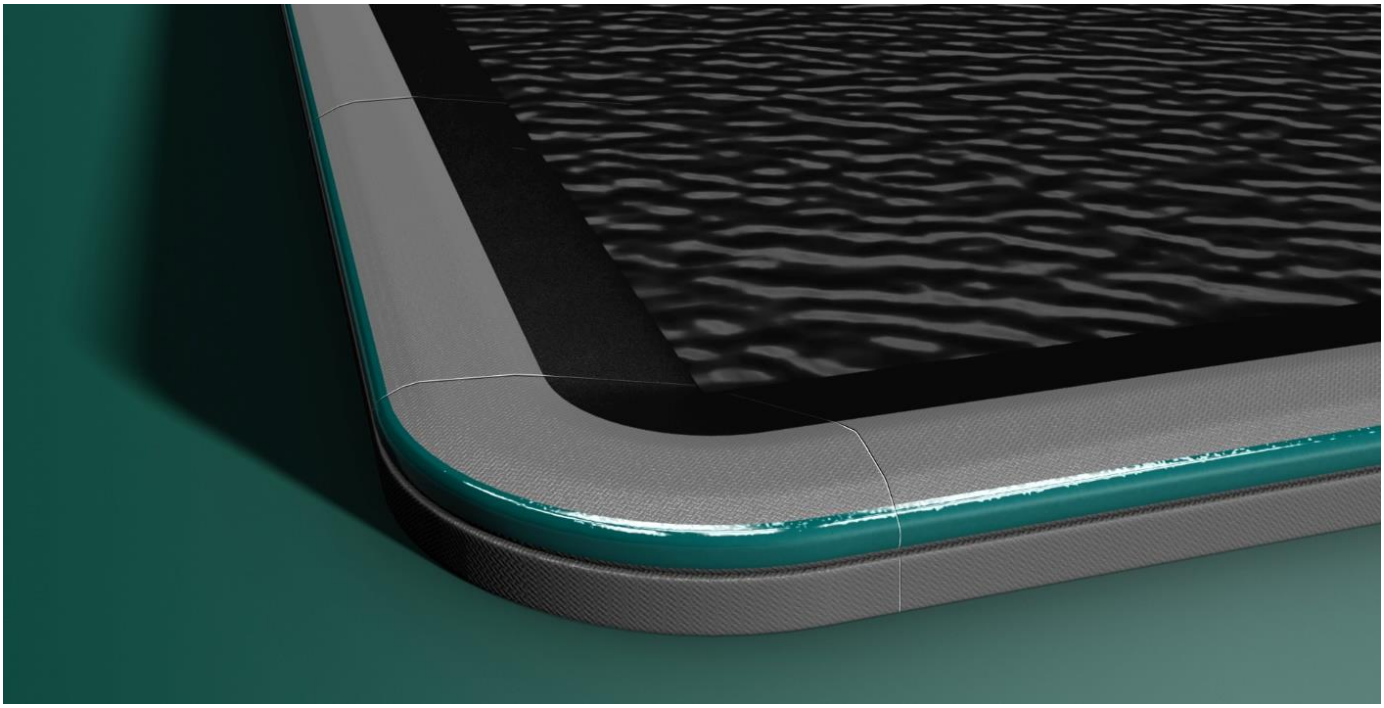


When combining these mats together, they create new impressions. This is done by that the thin top layer folds into the bumps of the layer below, if such are present. In this manner this gives the mat a surface roughness and a compliance, as well as the surface irregularity held by the mat below. Consequently, what is seen within the VR experience is mapped to what is felt, which is done before use by arranging the layers accordingly. Table 13 offers examples to how some grounds are realized by mat layer combinations.

Table 13 Examples of mat layer arrangements to simulate different ground properties.

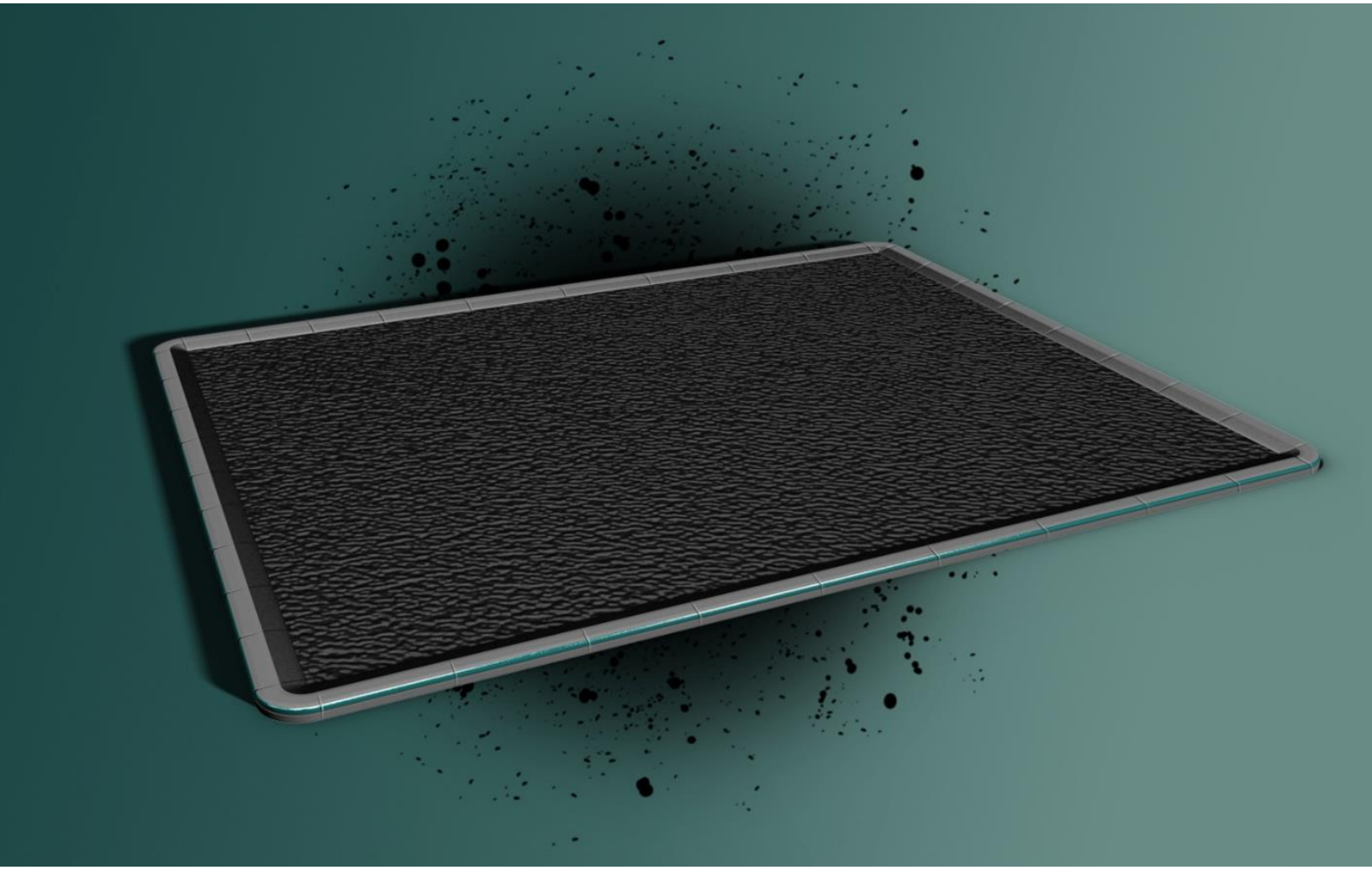
GROUND MATERIAL	MAT LAYER ARRANGEMENT
Grass	The rugged side of the roughness layer, placed on the irregular side of the uninflated softness layer.
Rocky beach	The smooth side of the roughness layer, placed on the irregular side of the hardness layer.
Sand	The rugged side of the roughness layer, placed on the irregular side of the uninflated softness layer.
Stone floor	The smooth side of the roughness layer, placed on the smooth side of the hardness layer.

Except for the combination of mat layers, a mat frame is also used. This frame consists of clam units that presses the layers together to hold them in place, which means that the edges of the mat cannot be kicked up. The frame also gives the mat arrangement a kept together and a professional look, while marking out where the virtual room is located in relation to the real room. As for the hard mat, the tiles are connected to the lower part of the clam with similar snaps used to attach the tiles to each other. The existence of this frame is important, as this low fidelity concept is supposed to be part of a high fidelity segment of products. Except from this, the frame also gives the mat a uniform and serious look, which is needed to fit among professional and technical products. The frame also serves to help defining the limits of the guardian grid, as the visualization of the guardian grid easily passes unnoticed as time goes. This is possible since the frame clams are units and all mats are adaptable in size, which means that the right size for the virtual room can be adapted to when obtaining the VR mat. The passive haptics that the frame offers, via a subtly applied tilt, consequently helps the user to notice this. This smooth transition from mat to frame means that it is not stumbled upon, while still alerting something that easily passes unnoticed as the experiences intensifies.



The visual design matches amongst the generally dark visual design of VR products, while using subtle cues intended to communicate values that attracts the potential users to feel entitled of use. This is achieved by having a light grey color on the frame, with a touch of color at the ends of the frame clam. The subtle cues are not reflected upon consciously, especially since the main mats are dark grey to sustain abrasion of frequent use. This subtle coloring is used since color alterations will communicate a down to earth feel and playfulness, emotions which the potential users might relate easier to, than being users of advanced technology. These choices together with the fact that the concept is "just a mat", which is easily exited when feeling done, can be useful to take down the nervousness many of the potential users feel in-before VR use.

The concept of the VR mat enhances the VR experience and offers a wide range of experiences, without the user consciously reflecting on how this has been technically realized, due to its subtleness. It offers a sustainable choice since it consists of no inbuilt technology, while the materials can be manufactured from recycled materials, and might be recycled again. Design for recycling is provided by the functionality of the product itself, since the materials are easily separated by the functionality itself, further simplifying recycling at end of use. This in-complicity in the construction means that a much lower price can be held in relation to the basic VR equipment, but also other accessories. Lastly, by using new design cues the concept's appearance matches the expectations regarding what VR products should appear like, while inviting the potential target group to feel entitled and secure in use. Overall, the VR mat offers a low fidelity solution to the complexity of creating immersions into virtual worlds.



7.4 Discussion

A feet haptic VR mat has been presented, that via different layer combinations of mat properties offers ambient and in-specific passive haptics to what is seen in VR. The functionality therefore heavily relies on the design of the mat layers and that they hold the assigned properties. Therefore, the first step is to manufacture such material mats, due to them holding these specific demands and qualities. The in-complexity of the mats however means that it is not necessarily impossible to find pre-manufactured materials to use, as these properties of the mats are specific yet not entirely uncommon in their executions. From the perspective of DigitasLBi, this concept offers creating a functioning and inexpensive prototype is possible.

The design of the mat concept is based on the result from the studies of this project, meaning that the haptic properties were indirectly tested via the user test. However, the exact inventory of haptic impressions used to develop the mat properties, and a user test with a prototype of this mat, has not been executed to verify the functionality. The performed user test did however offer rich insights about feet haptic perceptions for VR experiences, and what enhances these and not, which motivates the given haptic functionalities of the mat. Additionally, the in-complexity of the design and construction of the product means that even though the concept is a theorized one, it should be reasonable to function. However, to further develop a functioning product of this design, verifying user tests should be performed, and manufacturers should be contacted. Regarding the latter one, finding a manufacturer should not be difficult, since the attention VR brings means that many manufacturers could be interested in participating and collaborate regarding such a popular product that VR means.

Since the concept is a mat, it is only applicable for experiences that are restricted to a specific location, but also that the VR ground cannot change too dramatically within the experience. This means that infinite walking is not possible with this design, but also that only a specific set of ground experiences can be tolerated for the passive haptics to make sense. Restricting the possibilities to walk infinitely is however reasonable, since even though it is likely for high end VR headsets to go cordless in a near future, the real world rooms will probably not turn any bigger. A detained area of VR use will probably still be the case for the future uses, as well as the tracking of the user's location might still be located to a finite area. Regarding, that the passive haptics cannot change once the user enters the experience could however mean problematics for experiences of longer uses of time and those having big alterations in ground properties. However, as the VR experiences of DigitasLBi often are of shorter time limit, this means that the reasonable amount of ground properties switches decreases. In addition, the actual switches of ground properties are commonly not being of highest priority, nor determining the main functionality of the experience. Also, since feet haptics was found to offer an increased immersion without making the experience turning too realistic, it is therefore a reasonable consideration to adapt the ground properties visualized to not consciously change that dramatically. Incremental visual alterations could still be accepted by the user, since the brain strives to make ends meet regarding what is perceived by the senses,

but also since similar mat arrangements are used for several visual representations. However, for experiences not having similar considerations as those of DigitasLBi, or for those experiences holding functionality primarily relaying on accurate feet haptics, could mean that the concept is un-useful. The permanent execution of the haptics could therefore pose a problem, why some of the more technical concept ideas might be more beneficial.

A part of the concept is making use of new design cues, in order to make the potential users feel secure and entitled to use the commonly perceived highly technical VR equipment. An alteration of the visual design of the equipment is necessary to attract a bigger audience, since the current design is a consequence of technical restrictions as well as who uses VR right now. The appearance might however be dismissed as too subtle to make a difference for this purpose, since the VR mat is not the main product, why the feet haptic functionality itself might generate the perspective of the mat only giving a side function to the main function. The latter have been discussed previously, both in terms of the feet's important insensitivity in enhancing the experience, and also in that a solution is not specifically requested does not mean that it is useful. However, the visual design is not user tested specifically regarding what emotions that are elicited. Even so, as the appearance of the product is crucial to attract a wider group of users, since the current designs are heavily influenced by technology and gaming, it is important to at least strive towards altering the design. The design should be seen as an example of how the appearance might be altered in order to reach more users, rather the visual design for this purpose.

7.5 Conclusion

In this chapter, the VR mat was introduced that via passive haptics offers an enhanced immersion into VR without making the experience turn uncomfortably realistic. The concept is a low fidelity accessory, which makes use of different layers of mats having different properties in terms of material compliance, surface irregularity and roughness. By arranging these mats in different configurations, different haptic experiences can be achieved by matching a configuration towards what is visually seen in VR. It also offers a sustainable choice due to that the concept by itself depends on being possible to dismantle which supports recycling, as well as not including any technology and favoring being manufactured by reused plastics.

The mat layer arrangements are kept together by a frame, which serves to keep the mats in place while offering a kept together and professional look. Color and material choices strives to communicate a more down to earth and playful feel. This might be easier to relate to if not feeling like a gamer or a citizen of the future, which are cues the general VR product designs uses. What is communicated by the concept's appearance is therefore not only important for the concept to fit in, as the concept is a very low fidelity product in a field of high fidelity products. It is also important since VR needs to attract a wider target group of users, which is currently not achieved. The current visual design of VR products partly provides to this by being heavily technology and gaming influenced, which rather could make the potential users feel uninvited and reinforce the insecurity many perceive regarding VR. The alteration in the visual appearance is therefore just as important as the content in order to reach out to the users, which this concept illustrates an example of. Lastly, the VR mat provides the right type of haptics, found in the user studies to most enhance the immersion, while not breaking the promise to the users of making the experience uncomfortably realistic.

8

Overall discussion and conclusion

Overall discussion

In this master thesis project, the user perspective of haptic VR experience design has been approached, in terms of how the users respond and what they want to perceive. Investigating and researching this was necessary since the general product development until this point naturally has considered the technological perspective of making VR possible. As the technology now is available, for everyone that is interested, it is therefore important for VR to step out of the gimmick zone and investigate the use of it. This also means that the high expectations surrounding VR, which until this point has been crucial for many stakeholders to gain investments, now could mean a threat. The common discussion regarding VR has often been that everyone can use VR for every purpose, and that it is *the* future. These messages are often combined with visual representations of what such a future would look like, even though these seldom are representing a content or functionalities that exists. The users not being well settled in how VR technically works consequently have unreasonably high expectations on a performance and broad usefulness - which VR currently cannot live up to. That important VR stakeholders communicates an inaccurate picture about what VR can offer today, means that the VR business soon poses a threat to itself.

Even though this posing a threat, there is no doubt that this time VR is here to stay. This is due to that even though there is a lot to be learned and discovered about interaction and experience design in VR, the technology already holds unique functionalities for many businesses for it to pass by unnoticed, e.g. cost and time potentiation, prototyping and visualization. Any predecessor to the current high-end VR technology, which held a much higher price, did not offer such functionalities. Nevertheless, as suggested in the Pre-study, high-end VR might not achieve a broad public use if not an additional factor plays in. Adding to this, as also found in this research, there are other obstacles facing VR, due to that the enclosure of VR brings new problems e.g. the risk of users bumping into real world objects. For this purpose it is more likely that it will be the AR technology that breaks through as the virtual medium that reaches a mass adoption, except for cases where a real world disconnection is part of the desired functionality.

The process of this project approached the development of a feet haptic VR accessory from a holistic point of view, to offer DigitasLBi general insights about user experience design as well as specific insights into haptic design. Therefore, the initial scope was very broad, which consequently made the research broad. A risk with a broad research is however that no depth is reached, and that more questions in the end are posed than answered. It could have been beneficial for the research to have been narrower, and focused upon a specific body area for just a specific use case. However, such results were considered to quickly turn irrelevant. This due to such results only applying to one experience, combined with the fast development pace held in the VR technology segment. That the VR technology is being in its infancy also means that general insights are more useful and might be more quickly applied into a design. But most importantly the feet proved to hold the unique features of important insensitivity, which means

specific insights that rather supports a general solution. For these purposes this broad research can be considered to offer both general and specific results.

The main scope of this research was to investigate what role haptics can play in enhancing the experience and its functionality, and particularly feet haptics were deemed interesting for this purpose. As previously discussed, feet haptics hold great potential since it offers the increased immersion that haptics means, while not making the experience too uncomfortably realistic which is a consideration of the users. Even though the case was that feet haptics could easily and successfully be used to enhance the experience, it is still relevant to question its existence. This due to that the users only want haptics for experiences that cannot not hurt them in any way – cognitively or physically. This study has consequently given insights in what to regard when designing feet haptic VR experiences, where these furthermore might be of general use to understand design of user experiences in VR. The result does not mean that VR has to incorporate haptics for the best experience – especially since the users currently does not expect it. This means that the hassles of developing haptics to VR might be unnecessary. At this point, it is more reasonable for the overall VR experience to put time and effort into creating meaningfulness, value and functionality to figure out where VR can come to its fullest use, rather than developing haptics for all experiences. Specific experiences having a functionality that relies on an increased immersion might benefit from incorporating feet haptics, since these offer a safe yet increased immersion, as this study found. Additionally, if the experience specifically makes use of objects characterized by feet haptics, again such are useful to include. But until the immersive technologies are more specifically developed and adopted among a bigger audience, incorporating any haptics generally implies unnecessary workload and a shift in focus from what is most important – delivering meaningful and useful content that can match the users' expectations.

Overall conclusion

In this master thesis project, user experience and feet haptic design for VR has been researched to be useful for the digital communications and technologies agency DigitasLBi. Haptics refers to human machine interactions simulating the somesthetic sense, e.g. touch and perception of body positioning. The research has been done primarily from the perspective of the incoming VR users and their considerations, but also from the perspective of relevance in the future uses of VR and feasibility in the VR activities of DigitasLBi, commonly being VR showrooms and event experiences.

The focus of feet haptic design originated from a Pre-study, where development factors, trend and future analyses determined the most likely use areas of VR to be social functions, gaming, business use, marketing, military uses, science, all societal institutions and functions as well as climate changes related uses. Matching these against uses of haptics in certain body areas and need of a general product, feet haptics stuck out as an interesting area of focus, since the feet are in constant contact with the ground, gathering information about the state of the context.

By sending out surveys, investigating the current users' perspectives and problems in VR, balanced against the considerations of the potential users to come, conclusions could be drawn regarding how their evaluations of VR might differ. The current users are characterized by being early adopters, holding great faith in VR. They also hold understandings in the technical limitations VR currently has, why some problematics are sometimes overlooked. This differs from the potential users, whom have high expectations on VR instantly delivering meaningful content and value - but also questions it in terms of being a gimmick or anti-social. As a consequence, experiences will be evaluated and perceived thereafter. This implies a clash since the VR technology is still in its infancy. Since VR previously has been targeting primarily early adopters, there is also a risk that the potential users will not feel entitled to use this technology. This has both to do with them holding a lower technology self-confidence, but also by them not being attracted by the common visual communication the VR equipment currently holds.

User studies performed during this project found that the feet are unconsciously important for the evaluation of virtual contexts, while enhancing VR experience by increasing the immersion. These also showed that VR holds a promise about being real without turning too real, and incorporating haptics broke this expectation. Due to the feet being less sensitive than other body areas, it was found that offering in-specific and ambient feet haptics that holds consistent qualities over the whole experience, could be used to increase the immersion and enhance the experience, while still being safe and not turning uncomfortably realistic to the user. Furthermore, some feet haptic impressions were found to have greater impact on the experience than others. These were found to be distinct hardness changes, shapes and rough textures, which to some simulated differences in height, something that also made a great impact on the experience. In addition it was found that assigning feet to the user when offering feet haptics were not only sought after by the users, but would also increase the users' performance and motion accuracy.

Stemming from this research, a concept design was created which exemplifies how this knowledge can be incorporated into a feet haptic VR accessory, which holds usefulness for the activities of DigitasLBi. This concept is the VR mat, which via passive haptics from different material layer combinations gives ambient and in-specific haptics to the experience, which enhances the immersion into the VR experience without breaking the promise of turning too real. Consisting of size customized mats the VR mat holds the same size as the virtual room, and uses frame clams to smartly keep the layer arrangements together. This means that the little tilt of the frame clams alerts the user when risking to step outside the guardian grid and bump into real world objects, which was a common problematic found. The functionality of the layer arrangements also means that the mat supports a circular system at end of life, since it relies on being able to pull apart and therefore is easily recycles. That the mat supports being made of recycled plastics and has no inbuilt technology, also contributes to the sustainability. The visual design of the VR mat holds a kept together look by the frame and uses new design cues of light coloring, together with the dark characteristics of VR products. This light coloring communicates playfulness and a more down to earth feel, which might be easier to relate to for the potential users, rather than being users of advanced technology. All in all, the VR mat attracts a larger target group than currently reached, while being a sustainable solution that from a user perspective safely enhances the immersion into VR.

References

Literature

Andersson, A. (2017) Kan VR fungera som medium för empati? VR Sverige. URL: http://vrsverige.se/vr-och-empati/ (2017-04-13)

Dagman, J., Karlsson, M. and Wikström, L. (2010) Investigating the haptic aspects of verbalized product experiences. Gothenburg: Chalmers University of Technology.

Design Council (2007) A study of the design process. The Design Council. URL: http://www.designcouncil.org.uk/sites/default/files/asset/document/ElevenLessons_Design_Council%20(2).pdf (2017-01-24)

Desmet, P.M.A. (2003). Measuring emotions; development and application of an instrument to measure emotional responses to products. Delft: Delft University of Technology.

Bjerneroth, G. (2005) Sinnen – Känsel. In 1177 Vårdguiden. URL: http://www.1177.se/Vastra-Gotaland/Tema/Kroppen/Nervsystemet-och-sinnesorganen/Sinnen/#section-4 (2017-02-09)

Björk, F. (2014) Fler närsynta barn med ökat skärmtittande. SVT Nyheter. 2014-06-09. URL: http://www.svt.se/nyheter/inrikes/fler-narsynta-barn-med-okat-skarmtittande?hls=true&regionalmeny=1&gmenu=0 (2017-04-13)

van Boejien, A. et. al. (2013) Delft Design Guide. 2nd edition. Amsterdam: BIS Publishers

Botvinick, M. and Cohen, J. (1998) Rubber hands 'feel' touch that eyes see. Nature. 1998-02-19. URL: https://webapps.pni.princeton.edu/ncc/publications/1998/BotvinickCohen1998Nature.pdf (2017-07-11)

Buckle, C. and Mander J. (2016) GWI Trends - Virtual Reality, Q3 2016. Global Web Index. London: Trendstream Limited

Bye, K. (2017) #502: An Elemental Theory of Presence + Future of AI & Interactive Storytelling. [Voices of VR Podcast] URL: http://voicesofvr.com/502-an-elemental-theory-of-presence-future-of-ai-interactive-storytelling/ (2017-04-11)

Chillot, R. (2013) The power of touch. Psychology Today. 2013-03-11. URL: https://www.psychologytoday.com/articles/201303/the-power-touch (2017-05-16).

Chillot, R. (2013) Surface impact. Psychology Today. 2013-03-11. URL: https://www.psychologytoday.com/articles/201303/surface-impact (2017-05-16).

Christianson, S. (1992) The handbook of emotion and memory: research and theory. [Electronic] Mahwah: Lawrence Erlbaum Associates, Inc.

Cooper, A. (2015). Putting personas to work. San Francisco: Cooper, and co.
Cited in: A. Ilama (2015) Creating personas. UX Booth. 2015-06-09. URL: http://www.uxbooth.com/articles/creating-personas/ (2017-05-22)

Cronin, B. (2015) The hierarchy of needs in virtual reality development. Medium. 2015-01-18. URL: https://medium.com/@beaucronin/the-hierarchy-of-needs-in-virtual-reality-development-4333a4833acc (2017-04-11)

Davis, N. (2016) Long-term effects of virtual reality use need more research, say scientists. The Guardian. 2016-03-19. URL: https://www.theguardian.com/technology/2016/mar/19/long-term-effects-of-virtual-reality-use-need-more-research-say-scientists (2017-04-13)

Desmet, P. M. A. (2002). Designing emotions. Delft: Delft University of Technology.

Desmet, P. M. A., Porcelijn, R. and van Dijik, M. B. (2007) Emotional Design; Application of a Research-Based Design Approach. [Electronic] Berlin: Springer Science + Business Media.

El Saddik, A. et. al. (2011) Haptics technologies – Bringing touch to multimedia. [Electronic] Berlin: Springer-Verlag Berlin Heidelberg

Google Cardboard team (2015) Cardboard Design Lab. [Google Play]. URL: https://play.google.com/store/apps/details?id=com.google.vr.cardboard.apps.designlab&hl=sv (2017-04-12)

Hickman, C. (2016) #299: Using Magic to Create Astonishment with The VOID. [Voices of VR Podcast] URL: http://voicesofvr.com/299-using-magic-to-create-astonishment-with-the-void/ (2017-04-12)

Hodgson, E. (2014) #2: Eric Hodgson on spatial perception, redirected walking and the split between old VR vs. New VR. [Voices of VR Podcast] URL: http://voicesofvr.com/episode-2-eric-hodgson-on-spatial-perception-redirected-walking-the-split-between-old-vr-vs-new-vr/ (2017-04-12)

Hoffman, D. interviewed by Gefter, A. (2016) The case against reality. The Atlantic. 2016-04-25. URL: https://www.theatlantic.com/science/archive/2016/04/the-illusion-of-reality/479559/ (2017-04-12)

HTC Vive (2017) VR for impact - Example experiences. VR for impact. URL: https://vrforimpact.com/ (2017-01-30)

Insko, B. E. (2001) Passive haptics significantly enhances virtual environments. Chapel Hill: University of North Carolina.

Jaishanker, A. (2016) Virtual reality 101 – The different types of VR headsets. Your story. 2016-06-21. URL: https://yourstory.com/2016/06/virtual-reality-headset/ (2017-01-24)

Jones, L. (2009) Thermal touch. In Scholarpedia. URL: http://www.scholarpedia.org/article/Thermal_touch (2017-04-12)

Kawakita, J. (1991) The original KJ method. Tokyo: Kawakita Research Institute

Kishino, F. and Milgram, P. (1994) A Taxonomy of Mixed Reality. IEICE Transactions on Information and Systems. 1994-12-25. URL: http://search.ieice.org/bin/summary.php?id=e77-d_12_1321 (2017-01-24)

Kohli, L. (2013) Redirected Touching. Chapel Hill: Department of Computer Science, University of North Carolina.

Kohli, L. (2016) #351: Redirected Touch: Using Perceptual Hacks to Create Convincing Haptics. [Voices of VR Podcast] URL: http://voicesofvr.com/redirected-touch-using-perceptual-hacks-to-create-convincing-haptics/ (2017-04-12)

Kujala, S. et al. (2011) UX Curve: A method for evaluating long-term user experience. Interacting with computers. Amsterdam: Elsevier

Leif Arvidsson AB (2017) Petex Täckmatta. Peter Arvidsson AB. URL: https://www.leifarvidsson.se/petex-tackmatta-10m-rulle-bredd-1m (2017-05-28)

Ludden, G.D.S., Schifferstein, H. N. J. and Hekkert, P. (2006) Sensory incongruity: comparing vision to touch, audition and olfaction. Delft: Delft University of Technology.

Madary, M. and Metzinger, T. K. (2016) Real Virtuality: A Code of Ethical Conduct. Recommendations for Good Scientific Practice and the Consumers of VR-Technology. Frontiers in Robotics and AI. 2016-02-19. URL: http://journal.frontiersin.org/article/10.3389/frobt.2016.00003/full (2017-04-13)

The Natural Step (2016) Sustainability principles. The Natural Step. URL: http://www.thenaturalstep.org/our-approach/ (2017-01-26)

Painter, L. (2017) Best VR accessories 2017. Tech Advisor. 2017-06-29. URL: http://www.pcadvisor.co.uk/buying-advice/game/best-vr-accessories-2017-coolest-vr-accessories-3643903/ (2017-01-24)

Penfield, W. et. al. (1937). Somatic Motor And Sensory Representation In The Cerebral Cortex Of Man As Studied By Electrical Stimulation. Brain. 60 (4): 389-443.
Cited in E. Inglis-Arkell (2010) How your brain sees your body: Meet the cortical homunculus. Gizmodo. 2010-10-21. URL: http://io9.gizmodo.com/5670064/how-your-brain-sees-your-body-meet-the-cortical-homunculus (2017-02-09)

Reality Technologies (2016) Mixed Reality. Reality Technologies. URL: http://www.realitytechnologies.com/mixed-reality (2017-01-24)

Robertson and Zelenko (2014) Voices from a virtual past. The Verge. URL: https://www.theverge.com/a/virtual-reality/oral_history (2017-05-17)

Robles-De-La-Torre, G. (2006) The importance of the sense of touch in virtual and real environments. IEEE MultiMedia. 2006-08-07. Volume: 13, Number: 3, Pages: 24-30. URL: http://ieeexplore.ieee.org/document/1667971/ (2017-04-12)

Robles-De-La-Torre, G. (2006) IEEE International Symposium on Robot and Human Interactive Communication. September 2006, Hatfield.
Cited in D. Graham-Rowe (2006) The cutting edge of haptics. MIT Technology Review. 2006-08-25. URL: https://www.technologyreview.com/s/406335/the-cutting-edge-of-haptics/ (2017-04-13)

Rogers, E. M. (1962) Diffusion of Innovations. First edition. New York: Free Press of Glencoe.

Rovers, A. F. and van Essen H.A. (2005) Guidelines for haptics interpersonal communication applications: an exploration of foot interaction styles. London: Springer-Verlag London

Sabel, J. interviewed in Miljönytta (2013) Ökad efterfrågan I Europa på återvunnen plast. Miljönytta. 2013-09-14. URL: http://miljonytta.se/byggnader/okad-efterfragan-i-europa-pa-atervunnen-plast/ (2017-05-28)

Slater, M. (2009) Place illusion and plausibility can lead to realistic behavior in immersive virtual environments. Barcelona: ICREA-University of Barcelona

Srinivasan, M. A., Beauregard, G. L. and Brock, D. L. (1996) The impact of visual information on the haptic perception of stiffness in virtual environments. Cambridge: Massachusetts Institute of Technology.

Sustainable Virtual Design (2016) Virtual Reality and Sustainability I - Introduction. Sustainable Virtual Design. URL: https://sustainablevirtualdesign.wordpress.com/2016/11/07/virtual-reality-and-sustainability-i-introduction/ (2017-01-30)

Velázquez, R. et. al. (2012) Insights into the capabilities of tactile-foot perception. Aguascalientes: Universidad Panamerícana.

Pictures

In report

[3DRudder] n.d. [Electronic picture] URL: https://www.3drudder.com/developers/ [Retrieved 2017-05-28]

[Cerevo Taclim Shoes] n.d. [Electronic picture] URL: https://taclim.cerevo.com/en/ [Retrieved 2017-05-28]

[Cortical homunculus] n.d. [Electronic picture] URL: http://io9.gizmodo.com/5670064/how-your-brain-sees-your-body-meet-the-cortical-homunculus [Retrieved 2017-05-28]

[Cyberith virtualizer] n.d. [Electronic picture] URL: http://www.download3k.com/articles/Virtuix-Omni-vs.-Cyberith-Virtualizer-vs.-George-Burger-s-Infinadeck-Battle-of-the-First-Omnidirectional-VR-Treadmills-01153 [Retrieved 2017-05-28]

[Feelreal mask] n.d. [Electronic picture] URL: http://feelreal.com/ [Retrieved 2017-05-28]

[Gloveone] n.d. [Electronic picture] URL: https://www.researchgate.net/publication/297760223_State_of_the_Art_of_Virtual_Reality_Technologies [Retrieved 2017-05-28]

[Google daydream] n.d. [Electronic picture] URL: https://www.xda-developers.com/google-daydream-will-get-a-big-update-and-its-own-vr-web-browser/ [Retrieved 2017-05-28]

[Google cardboard] n.d. [Electronic picture] URL: https://store.google.com/?srp=/product/google_cardboard [Retrieved 2017-05-28]

[HTC Vive] n.d. [Electronic picture] URL: https://arstechnica.com/gaming/2016/10/best-vr-headset-2016-psvr-rift-vive/ [Retrieved 2017-05-28]

[KOR-FX] n.d. [Electronic picture] URL: http://www.ebay.com/itm/KOR-FX-Gaming-Vest-amp-Optical-Adapter-for-PS4-Xbox-One-PC-Sound-Card-/291724069918 [Retrieved 2017-05-28]

[Leap motion] n.d. [Electronic picture] URL: http://www.vicespy.com/leap-motion/ [Retrieved 2017-05-28]

[Oculus Rift] n.d. [Electronic picture] URL: https://www3.oculus.com/en-us/blog/oculus-rift-pre-orders-now-open-first-shipments-march-28/ [Retrieved 2017-05-28]

[Oculus touch] n.d. [Electronic picture] URL: http://www.ourarcade.com/hardware/input-devices/oculus-touch/ [Retrieved 2017-05-28]

[OnePlus The Loop] n.d. [Electronic picture] URL: https://www.digitaslbi.com/sv-se/work/oneplus-vr [Retrieved 2017-05-28]

[PlayStation VR] n.d. [Electronic picture] URL: https://www.playstation.com/en-us/explore/playstation-vr/games/ [Retrieved 2017-05-28]

[Reactive grip] n.d. [Electronic picture] URL: http://www.ourarcade.com/hardware/input-devices/ [Retrieved 2017-05-28]

[Roto VR] n.d. [Electronic picture] URL: http://www.rotovr.com/ [Retrieved 2017-05-28]

[Samsung Gear VR] n.d. [Electronic picture] URL: https://www.amazon.com/Samsung-Gear-VR-Virtual-Warranty/dp/B016OFYGXQ [Retrieved 2017-05-28]

[Teslasuit] n.d. [Electronic picture] URL: http://newatlas.com/teslasuit-full-body-virtual-reality-stimulation/41206/ [Retrieved 2017-05-28]

[Virtuix Omni] n.d. [Electronic picture] URL: http://www.virtuix.com/product/omni-package/ [Retrieved 2017-05-28]

[Virtuix Omni Tracking Pods] n.d. [Electronic picture] URL: http://www.virtuix.com/wp-content/uploads/2014/12/pods_product_3.png [Retrieved 2017-05-28]

[Vive Trackers] n.d. [Electronic picture] URL: https://www.vive.com/us/vive-tracker-for-developer/ [Retrieved 2017-05-28]

[VirZoom] n.d. [Electronic picture] URL: http://www.pcworld.com/article/3016358/hardware/exercising-in-virtual-reality-with-virzooms-bike-controller-sounds-fun-but-isnt.html [Retrieved 2017-05-28]

[Woojer] n.d. [Electronic picture] URL: http://vrca.de/resource/woojer-strap/ [Retrieved 2017-05-28]

In expression board

[Bent material layers] n.d. [Electronic picture] URL: https://lemanoosh.com/publication/auto-draft-172/#.WQmk9mTjZK0.pinterest [Retrieved 2017-05-10]

[Couple on a cliff] n.d. [Electronic picture] URL: http://www.sommerlanding.com/ [Retrieved 2017-05-10]

[Plastic shape corner] n.d. [Electronic picture] URL: http://lemanoosh.com/tagged/minimalist/ [Retrieved 2017-05-10]

[Urban ears Plattan] n.d. [Electronic picture] URL: http://www.selfridges.com/GB/en/cat/urban-ears-plattan-adv-edition-on-ear-headphones_875-10044-URBPLATTANADVGREY/ [Retrieved 2017-05-10]

[Wall tiles by Heather Knight] [Electronic picture] URL: http://cargocollective.com/klink/Artist-Heather-Knight [Retrieved 2017-05-10]

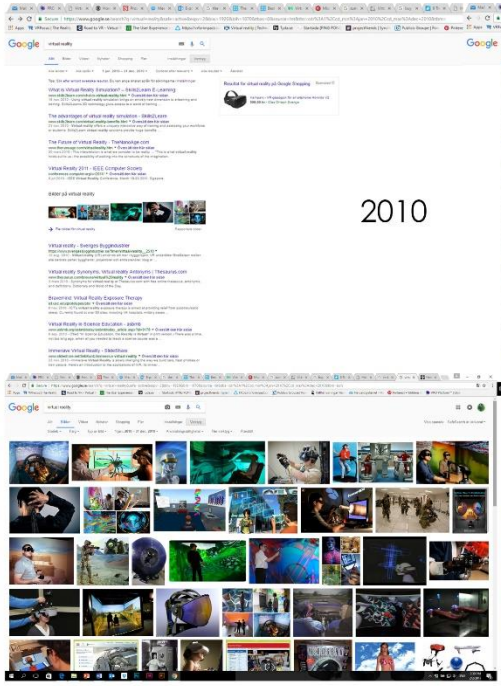
Appendix

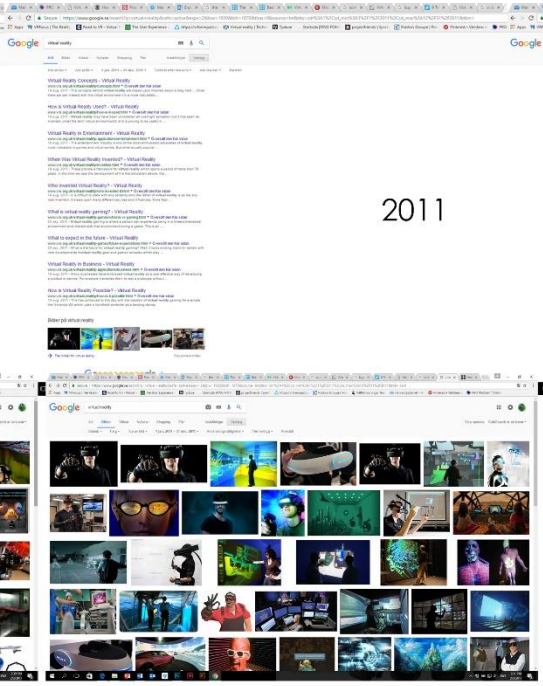
Content

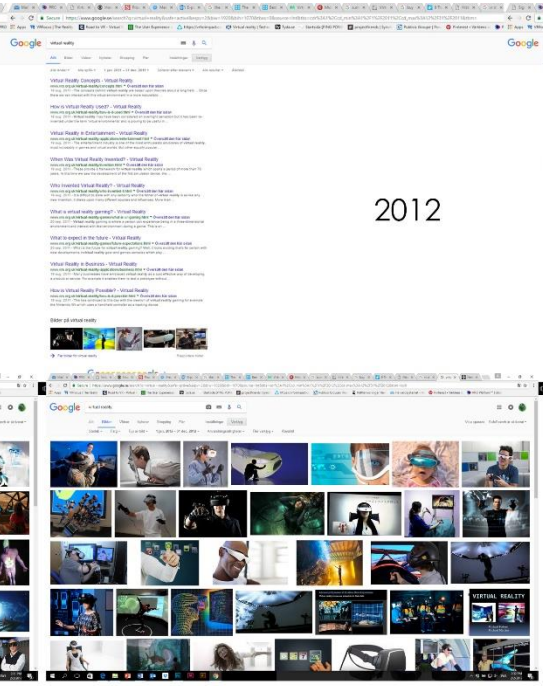
Appendix 1

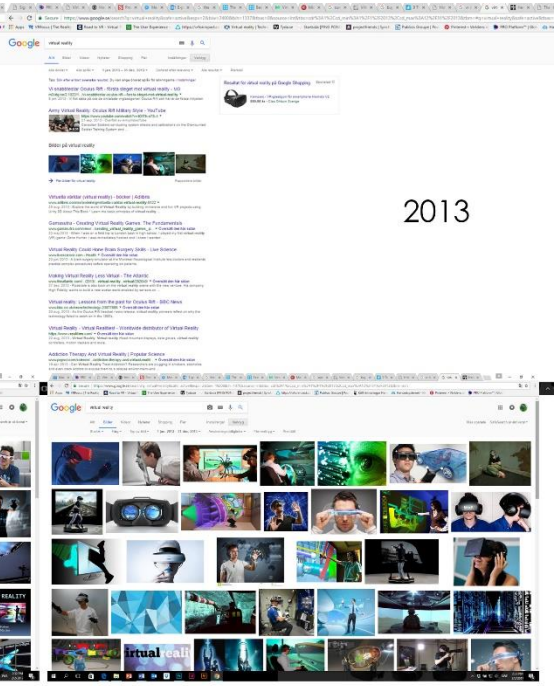
Google content analysis versus historic events

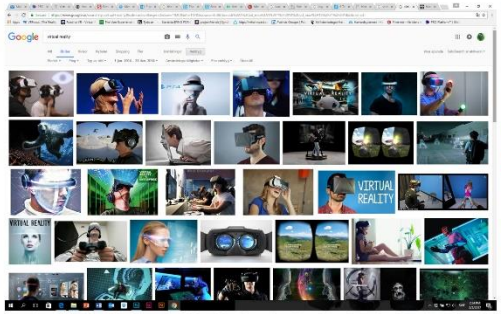
Year	Google search hits	Google titles content analysis	Google pictures content analysis	Events
2010	1 080 k	"What is VR" + advatages Future and Sci-fi Conferences (IEEE Computer Science) Therpeutic. Education, insights Applications and implications of VR Games	Boxy and CAD-isch Development focus from a technical perspective Pew-pew, cars and Sci-fi 1child, 1 naked woman, 1 woman rehabilitating fobias otherwise males	
2011	1 670 k	When and How? The future Games, and what else Medicare applications and therapy Social networking	Entertainment Sci-fi Pew-pew Technical focus Medicine Exploring	Iphone viewer (The Stanford Lab..)
2012	2 190 k	"Now it is happening!" Occulus Rift! … but are we ready? "Addictive and unhealthy" For gaming and rehab, 3D simulations	Technical Less "geeky" through portraying people from another perspective Tom Cruise 9 females and 1 child Offices? Phobia and horror? 1 architecture/civili engineering environment	Palmer luckey löser tidigare problem, John Carmack ger Occulus publicitet, Occulus fundraiser, Valve says they are developing VR.
2013	3 650 k	Occulus Rift tests The future – are we ready? Mobile VR Gaming Lessons leard from earlier, less virtual	Very technical and hi-tech Omnix threadmill Graphical representations of VR feeling Travel-Into-The-Computerzz Cars and pew pew 7 females (2 for phobia and horror) Occulus and such	Occulus DK1 releases, HTC is interested in VR.
2014	6 570 k	Occulus!!! Google cardboard!!! WOW! It's the future! VR sickness This is the next hard drug, death of morality Next big thing in education?	Occulus and smartphones Sci-fi and games Technicals 6 females High tech feel and pew-pew Pictures of headsets	Facebook buys Occulus (Valve och Occulus slutar att samarbeta), HTC och Valve börjar samarbeta, Occulus DK2 releases, HTC+Valves developer kit arrives, Google Cardboard is relaeased.
2015	13 400 k	"this will change the world" Hotter than ever Wow!! VR for all Good and bad	The headset designs we see today Front-face pictures of users using VR-headsets Neutral environments Gaming and offices	Samsung VR Gear is released,
2016	32 600 k	Wow and experiences "The best of.." different things "One year out – what have we learned?" Future branches Will it change your life?	People doing stuff in VR, portraited up-front Entertainment and Sci-fi Offices and such saying VR is useful everyday, for everyone, everthing and everywhere	Occulus Rift and HTC Vive are commercially released, followed by Playstation VR, HTC Vive says they are going cordless in late 2016
2017 (until 2nd of February)	43 400 k	Pricerunner AR and VR The Facebook and Occulus trials that are going on Use cases: Super bowl, afraid of speaking publically, pain of surgery, resident evil Add scent - what happens? Marketing Flopping?	Organisations and companies: FB and NASA Not only entertainment focus but still very sci-fi	

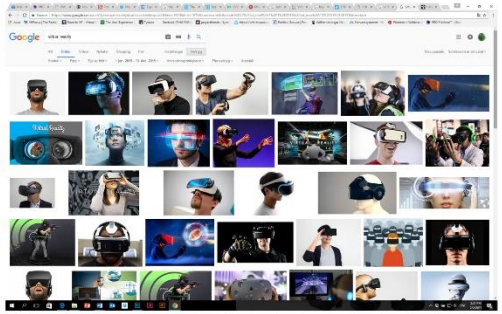

2010

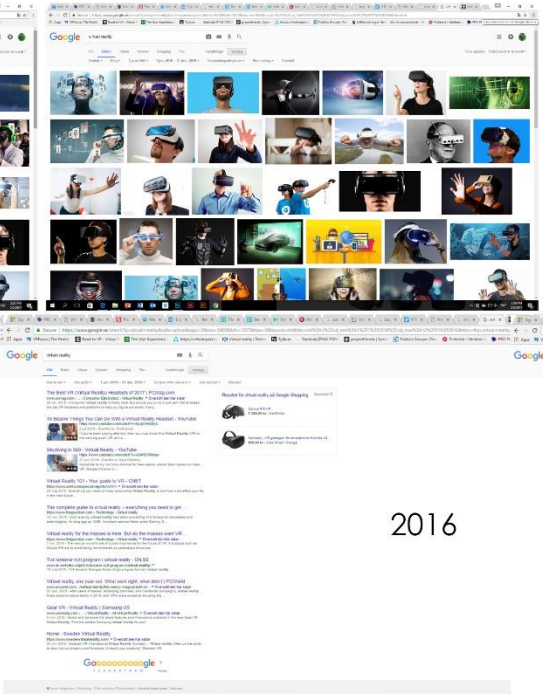

2011

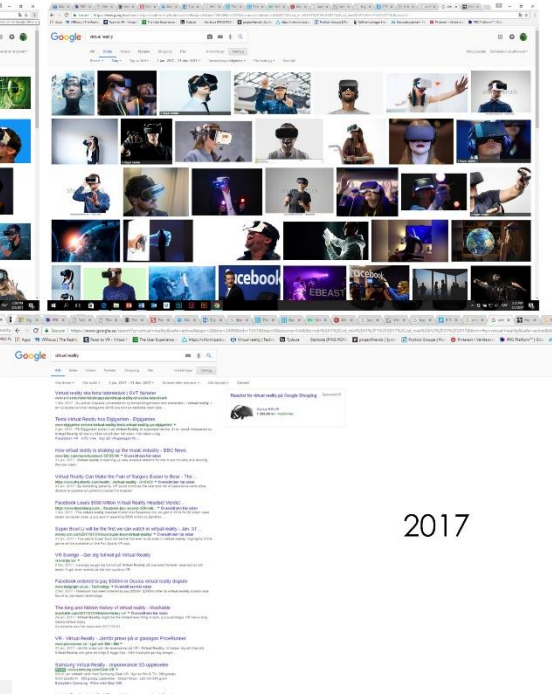

2012


2013


2014


2015


2016


2017

Appendix 2

Content trend analysis regarding future VR use areas

Entertainment	Businesses activities	Healthcare	Education	Well-ness	Social	Society	Consumer activities	Science
27	16	11	14	5	2	12	11	5
Movies and theartre 7	*Meetings, workspace and productivit 5*	Pain relief 2	*Education 7*	Meditation (and pilgrimage) 4	Networking, FB 2	Journalism (empathize) 4	Shopping (+ test-drive a Volvo) 6	(Big) data visualizatio, demonstrate models and technology 4
Sport events 3	Marketing 4	*Therapeutic 5*	*Simulational training 6*	Work-outs 1		Justice (Courtrooms and crime investigation) 3	Room design preview (IKEA) 3	Space 1
Gaming experiences 10	Manufacturing and production 4	Diagnosis and treatment 1	Migraine experience (empathize) 1			Military 2	Home tours (rent or sales) 2	
Tourism 5	HR interviews 1	Rehab 3	Cognitive training 1			Artists (Tiltbrush) 1		
Music and festivals 2	Architecture and civil engineering 2					Living in VR due to environmental aspects 1		
						Museums 1		

High score:

Gaming experiences	10
Movies and theater	7
Education	7
Simulational training	6
Shopping (+ test-drive a Volvo)	6
Therapeutic	5
Meetings, workspace and productivity	5
Tourism	5
Manufacturing and production	4
Marketing	4
Journalism (empathize)	4
Meditation (and pilgrimage)	4
(Big) data visualization, demonstrate models and technology	4
Sport events	3
Rehab	3
Justice (courtrooms and crime investigations)	3
Room design preview (IKEA)	3
Music and festivals	2
Architecture and civil engineering	2
Pain relief	2
Networking, FB	2
Military	2
Home tours	2
HR interviews	1
Diagnosis and treatment	1
Migraine experience (empathize)	1
Cognitive training	1
Work-outs	1
Artists (Tiltbrush)	1
Living in VR due to environmental aspects	1
Museums	1
Space	1

Sources of the articles analyzed:

http://blog.ventureradar.com/2015/10/07/25-virtual-reality-use-cases-and-their-leading-innovators/ (2017-02-04)
https://techcrunch.com/gallery/7-unexpected-virtual-reality-use-cases/ (2017-02-04)
http://www.tomsitpro.com/articles/virtual-reality-business-use-cases,1-3497.html (2017-02-04)
https://medium.com/@bastianwilkat/virtual-reality-8-use-cases-that-show-vr-is-more-than-just-a-gimmick-e4475d88adb1#.7nb8lmas6 (2017-02-04)
http://www.datamation.com/data-center/virtual-reality-for-business-9-key-use-cases.html (2017-02-04)
http://www.roadtovr.com/?s=use+cases (2017-02-04)
http://www.softwebsolutions.com/resources/real-world-use-cases-of-virtual-reality.html (2017-02-04)
http://www.livescience.com/53392-virtual-reality-tech-uses-beyond-gaming.html(2017-02-04)

Appendix 3

Evaluation matrix over body areas versus most likely future use areas

Use area / Body area of haptics	Hand haptics	Head and neck haptics	Feet haptics	Torso and arms haptics	Legs haptics
Entertainment	X		X		
Gaming	X	X	X	X	X
Healthcare/theraphy/rehab	X	X	X	X	X
Education/training simulators	X		X	X	X
Military	X	X	X	X	X
Environment caused uses (living in VR)	X	X	X	X	X
Architecture/civil engineering	X		X		
Business activities/workspace and productivity	X		X		
Consumer activities/shopping	X		X	X	X
Science	X	X	X		
Social	X				
Work out/well-ness	X		X	X	X

Appendix 4

Workshop procedure and instructions

Workshop Brainstorming om haptiska VR möjligheter

Syfte: Vart finns potential? Vad är realistiskt att kunna göra något i linje med en idé som presenterats?

Vad workshopen går ut på: Denna workshop går ut på att vi ska brainstorma kring hur olika fothaptiska intryck skulle kunna realiseras i en produktassesoar till VR på ett någorlunda rimligt vis. Med haptik avses känselintryck som ges av kroppen i "action" och interaktion med omvärlden. Det innebär alltså:

olika typer av tryck, värme, smärta (cutaneous sense)
acceleration eller hastighet, hur/att man rör sig (kinesthetic sense)
uppfattning var kroppsdelarna befinner sig (kinesthetic/proprioceptic sense)

Varför just foten?
- Fotens känselupplevelser är väldigt viktiga för hur vi uppfattar saker, t.ex. balans, men den är inte direkt vårt mest känsliga sinne. Man kan säga att fotens haptiska intryck verkar indirekt på så vis, vi använder oss av intrycken med vi tänker inte på det.
- Dessutom är den ju hela tiden i kontakt med vår omvärlden och ger oss information.
- Därför är det viktigt att man för bättre VR upplevelser inkluderar fothaptiska intryck, i och med att det bidrar till att skapa det vi upplever som närvaro i en situation. Så, vår idégenereringssession ska handla om hur man lösa dessa med avseende på fothaptiska sensationer rent funktionellt/teknisk som en VR-haptisk assesoar? Sedan avsluta med en gemensan utvärdering av vilka sinnen som är tekniskt svårt-enkelt att göra något för? För att alla ska få sig en gemensam bild av vad VR är börjar vi med att testa en VR upplevelse som heter The Lab.

Fråga: Vilka har testat VR sedan tidigare? Får vara sist.
Uppmana: Säg allt vad ni känner och upplever rakt ut när ni är i VR – hellre en gång för mycket än en gång för lite! Inget är konstigt!
Enkät efter användning?Idegenereringsprocess

Brainwriting/-drawing: Hur kan man göra en fothaptisk VR-assesocar som simulerar upplevelsen av olika haptiska intryck.Tänk stort och abstrakt kring funktionalitet och lösningar. 4 minuter att komma upp med 3 eller flera idéer per haptisk kategori + öppen presentation och diskussion.

Regler:

1. Kritik kommer i ett senare stadie. Skippa kostnad och marknads realism för att sporra idéer.
2. The wilder the better.
3. Försök och tänka på kombinationer av idéer, egna och andras.
4. Kvantitet inte kvalitét.

Frågeställning: Hur kan man göra en fothaptisk VR-assesocar som simulerar upplevelsen av…

Strykningar: Olika typer av strykningsupplevelser. Hastighet och lätthet.
Textur och medgörlighet: Olika grader och typer av ytstrukturer; Strukturdjup och jämnhet. Olika grad av mjukhet och hårdhet; deformation.
Form, storlek och vikt: Olika formupplevelse; Global konturupplevelse. Olika storleksupplevelser av objekt, från liten till stor; Global objektuppfattning i relation till omvärlden. Olika tyngdupplevelser; Kraft för att flytta eller hålla ett objekt.
Varmt/kallt: Uppfattning av värme/kyla. Nervstimuli.
Rörelser: Upplevelse av rörelser av dig själv I relation till omvärlden.
Acceleration: Upplevelse av accelerationsstorlek.
Var kroppsdelarna är positionerade i rymden: Upplevelse av vart i rymden kroppsdelar befinner sig. Inre lägesmätning av senor och leder samt spänningar.

Öppen presentation av ens idéer och diskussion:

En kategori i taget
Spinn vidare på varandras ideer! Vilka idéer skulle kunna kombineras? Kan man utveckla idéer vidare tillsammans? Vad har vi för olika typer av idéer?

Alla kategorier
Vilka idéer skulle kunna kombineras? Vad har de olika typerna av idéer för gemensamt? Kan man utveckla idéer vidare tillsammans?

Utvärdering:
Vilka sinnen är svårt versus enkelt att göra något rent tekniskt med?

Appendix 5

Workshop results

Frågeställning: Hur kan man göra en fothaptisk VR-assesocar som simulerar upplevelsen av…

Strykningar:

Gemensamma idéer:

- Någon typ av sko eller strumpa att styra
- Små punkter av tryck, på nano-nivå
- En massagestol, en sådan slags funktion
- Något som är lite strävt, friktioner (friktion nästan mer viktigt här än för texturer)
- Kan man istället jobba med att strykningar på övriga kroppen förstärks av fötterna? Man behöver inte känna allt.

Inviduella idéer:

- Trådar som kan anta och stela efter olika former
- Gel som reagerar
- Roterande skoband
- Elektoder som stimulerar foten nerver eller hjärnan
- Tryckvindar i skorna som blåser
- Morphsuit
- Hjärnstimulation ocj elektriska signaler
- Larver
- Plagg med foder
- Alla olika material
- Vibration 2.0, utveckla något från kontroll
- Pjäxa som byter insida
- Fjädrar
- Massageoverall
- Matta med olika fält
- Massagestrumpa
- Vätska som rör sig och skapar en sensation
- Vibrationer, matta som vibrerar
- Material som ändrar styvhet (från pinne till fjäder)
- En robothand som gör saker
- Sko med vibrationsplattor och nylonsträngar, för en strykning aktiverar vibrationer där nylonsträngar finns
- Muskelstimulans, plattor på fötterna i olika strykor, morphsuit som drar ihop sig lokalt kring en elektrisk signal

Textur och medgörlighet:

Gemensamma idéer:

- Platåsko med spikar, sem den för handen (som finns på Universeum etc)
- Spikmatta, snabbt och realisktiskt
- Pjäxa med olika kornstorlekar
- En låda med ris och en bottenplatta som rör sig
- Gel man är i
- Tempurmadrass, tempurgel
- Spikmatta och gel, två lager

Inviduella idéer:

- Matta som kan ändra strukturer, t.ex. spikmatta
- Gelboll man kan sparka på
- Sån man kan trycka handen i som sula, massa små reglerbara pinnar
- Tyg som spänns/spänns upp som en sula
- Gå på små magnetiska kulor, pärlor som kan omformas fritt i mönster med magnetfält
- Gelsula med medgörlighet
- Tempurdyna att gå på
- Trycka ner tårna, endast treadmill, hela struktuen förändras
- Väggar i ett helt rum av tempurmadrasser
- Sko som klämmer åt, pjäxa, gympasko
- Spikar som ändrar längd i platåsko
- Vibration, en transformerande matta, typ luftmadrass, sjunka ned i olika grader
- Spännan gummiband, släppa gummiband
- Formbar spikmatta (leksak)som är olika trög beroende på var VR-användaren är
- Ett lager med ris som man står på och så styrs djupet av en bottenplatta
- Pjäxor på som innehåller olika kornstorlek, vibrator siktar kornen och byter plats inuti pjäxan för olika textur

Form, storlek och vikt:

Gemensamma idéer:

- Räcker det med att man får bara någonting, ändå tillräckligt. Vad är viktigtk i vilket sammahang, behöver man ha allt? T.ex. pilbågen kändes kanske inte exakt som en pilbåge
- Gör något bara, något helt annat än att avsiktigt efterlikna den riktiga världen ens
- Antingen efterlikna helt eller efterlikna något helt nytt och annat
- Plattor
- Fjäder från höft till sko ->ger vikt och känsla av seghet och mjuhet så man tror att man gå egenom något men man gör inte det

Inviduell idéer:

- Gummiband som sitter vid fötterna blir olika spända
- Kula i skor håller emot vikt
- Utomstående golv morphas
- Anpassningsbart golv,
- Planka i VR, planka i R
- Sko/strumpa, anpassningsbar tyngd i skorna. Vristtyngder, behöver inte bara tyngd Räcker med någon typ av haptisk feedback, typ hjärnan översätter tyngd?
- Matta med sektionerf, åker upp och skapar olika hinder. Fyllda med olika mycket material
- Sko med magnet till golvet simulerar vikt
- Koppel till foten
- Muskelstimulans plattor ger känsla av "mini-kramp", vilket får användarern att uppleva saker som tyngre
- Spiralfjädrar som fäster i höft mot sko, kan ge olika motstånd (skruvar som spänner)

Varmt/kallt:

Gemensamma idéer:

- Använda material istället, texturer och yto för att man tänker att vissa saker är varma, vissa är kalla. Material leder bort temperature olika snabbt , det gör att man uppfattar temperatur. Man behöver kanske inte varmt i sig, man kan ta hårt/blankt att säga kallt
- Vind och blåst
- Matta, stumpa och sula
- Indusktionsskor, induktionshällar
- Tryckreglering
- Smartsocks

Inviduella idéer:

- Värmesula/golv som snabbt byts, använda kall och varm gas som leds in för att byta temperatur fort, tryckreglering i skor för att göra den varm/kall fort
- Blås varm/kall luft
- Väme/kylsulor i skor
- Golvmatta som skiftar i temperatur
- Sockor med metalltråd, justera temperatur
- Stengolv,temperatur, textur, hårdhet
- Många intryck är i kombo m varandra – behövs alla stimuleras? Vilken är mest effektiv/lättast? Vad är viktigast för respektive känsla?
- En sula som är varm eller kall, induktion?
- En matta som är varm eller kall, induktion?
- En sko som stramar åt hårdare kring tår/anklar för mer värme
- Man står på ett air hockey-bord, blåser kallt
- Mindre värmeelement i skorna som alltid är på. Det ska finnas en block för elementet och en mindre luftström (tryckluft) för snabbkylning

Rörelser:

Gemensamma idéer:

- Olika typer av hamsterhjul, löpband, en sfär, en munk "med kondom runt", en tight konstruktion som kan röra sig i alla riktiningar
- Lufttunnel, jag rör mig, inte rummet
- Teleportera med fötterna, inte flytta sig med händerna som det görs nu, det är ju inte så man gör naturligt.
- Viktigt att man kan se fötterna.
- En fast golvlösning, som en segwaylösning, luta sig in i rörelsen
- En matta som skiftar i höjd
- Jätterum med supermjuka väggar
- Kroppsfotboll (en sån man har på sig och springer runt och mot saker utan att slå sig)

Individuella idéer:

- Löpbandet.
- Skor; är egentligen svävande/upplyft men låter skorna göra så att det känns som att man går vid tryck i sulan
- Man har ett jätterum med mjuka väggar. Så det är ok att krocka
- Golvet vrider på en
- Rullaskridskor som "justerar/placerar dig rätt"
- Hamsterhjul
- Matta /golv som skiftar höjd långsamt – gå – löpa – snabbt
- En sfär, ett löpband
- Framkalla känslan av rörelse mha fartvind? Alternativa lösningar
- Runt med kondomöverdrag – rörelse i alla riktningar
- Sväva fritt i rummet, med en tunnel
- Teleportera sig genom att använda fötterna – "press" virtual fotknapp

- Rullband
- Studsmatta; hoppa och hoppa mycket längre än man trott i VR t.ex. på en häst
- Man står i en skål med fixerade kullager – längre ut från centret (brantare) kräver att man rör sig snabbare.
- Står på en jätteglatt yta så att man trampar på samma ställe. Skosulan är gjord relativ till det glatta materialet och positionerar användaren på plattan
- Friktionsfritt
- Hjul på skorna
- Något som rör sig
- Jag rör mig inte men rummet rör sig eller jag rör mig
- Ha fysiska plattor/"labs"/banor/öppna hallar

Acceleration:

Gemensamma idéer:

- Behövs det verkligen? Vad behöver man veta? Tåganalogin.
- Som att rycka undan en mattan
- Överdriva känslan i VR bara? (det visuella/ljud)
- Tryckändring i tårna, trycker mer för att ändra
- Platta som man står på
- En kraftanstängning krävs
- Känslan av att man rör sig

Individuella idéer:
- Tyngd/lätthet
- Gummibandsgrejen
- Magnetiskt fält skapar tröghet/täthet att röra sig. Magnetisk sko och underlag
- Vind om det går jättefort
- Rycka undan mattan
- Höj och sänkbart golv
- Måste accelerera riktat i rätt riktning
- Fötterna hamnar lite bakom, förflyttas bakåt, "rullbandet"
- Ryck i skorna
- Ge känslan av att gå till springa genom tryck i tårna. Känna tårna?
- Vindmotstånd
- Högre tryck i framfoten vid accelerationsändring
- Överdriva accelerationen i VR-världen
- Behövs den?

Var kroppsdelarna är positionerade i rymden:

Gemensamma idéer:

- Förstärka benens tyngd mha vikter
- Man får känna med handen på sina fötter och se det i VR samtidigt så man vet att de är där
- Att allt sitter ihop, kroppen
- Se fötterna, underligt att inte se
- Man känner att saker händer (alla de andra intrycken)
- Kan man göra något så man har flera ben

Individuella idéer:
- Ha ben och andra lemmar, inte bara händer
- Hanskar/strumpor – morphsuit
- Är meningen egentligen att efterlikna riktiga världen eller är den egentligen en möjlighet att helt balla ur och skapa andra världar där andra fysiska lagar gäller?
- Tryckstrumpa etc.
- Upplevelse av av tidigare intryck skulle skapa en sådan känsla
- Man får "känna på" foten med hand eller verktyg som då ger verkliga/overkliga känselintryck
- Andra kroppar än fötter
- Överför känslan till sjöjungfrustjärt etc.
- Hur vet jag vart jag har mina kroppsdelar? Förstärka verkligheten genom att hålla tag i foten
- Kontrollera genom värme
- Vibrationer som med pilbågen
- Dragplåstret: handkontroller, att man ser sina fötter + händer
- Vatten – återkoppling med kyl, strumpa osv
- Förstärka de ytor man rör vid mha 2,3,4 (ges naturligt genom att förstärka andra upplevelser)
- Tracker, fejkfötter. Sänder ut ljus. Tracker på sin tass.
- Fejkfot i VR, ange storlek.
- Mattan känner av vart du står och visar i VR
- Sensor i häl och framfot som hjälp att navigera datorbilder, om man flexar foten så känner sensorerna av positionen i förhållande till varandra. Ju mer ökad spänning desto längre ifrån kroppen.
-

Öppen presentation och diskussion:

Vad kan kombineras?

- Textur, medgörlighet, form, och temperatur (vikt och storlek) -> proprioception
- Olika saker med tryck via vibrationer och värme
- Proprioception skapas när man har de andra, man skapar illusioner om vissa intryck genom att man ger vissa intryck

Utvärdering:

Vilka sinnen är svårt versus enkelt att göra något rent tekniskt med?

- Svårt: Strykningar, acceleration, hur man rör sig. Vikt och ev storlek.
- Enklare: textur, medgörlighet, form, temperatur, proprioception

Vart finns potential?

- Illusioner
- Vibrationer för att ge tryck, sånt som redan finns
- Värme
- En slags sko
- Ett underlag
- Matcha med ljudintryck
- Matcha med ljud och bild generellt tillräckligt, eller ge överdriva saker vi dem så man inte behöver ge så myckey feedback alls
- Man behöver inte göra så som det verkligen är, bara något. En vibration behöver inte kännas så som det faktiskt gö när jag t.ex. spänner pilbågen

Vad är realistiskt att kunna göra något i linje med en idé som presenterats?

- Low hanging fruit: Att göra något med fötterna som i att tracka fötterna
- Relevans – inte strykningar
- Vibrationer på fötterna
- Tryckgrejerna -> högtekniska vibrationer och värme
- 90% av tiden är vi ju i skor ändå så varför ska vi ge det realistiskt ändå? Ta istället vad man kan känna igenom en sko. Hur dova stötarna är när man går (m sko)
- Ljudet ska matcha och bekräfta med det man känner. Känns det dovt ska det låta dovt. Det ska stämma överens med kroppen och vad man gör.
- Jobba med det enkla, det som finns
- Några olika typer av intryck och sen olika intesitet av dessa.
- Vibrationer är välanvända och funkar
- Kombinera olika intryck
- Designa visuellt

Observationer och kommentarer när de testade VR:

- "Men, hur använder jag kontrollerna?"
- Snart följt av: "Det här är ju grymt!" och "Wow!"
- Deltagare som var väldigt nervös inför VR-upplevelsen: "Det är ju väldigt snällt att lägga in en sån här [refererar till hundroboten i The Lab] för nu känns det väldigt snällt"
- Deltagare så fort HMD kom på: "Oj, åh jag kommer bli åksjuk" ... men blev ej det.
- "Var är mina fötter!? Nej!!"
- Samtliga deltagare behövde instrueras om hur kontrollerna fungerade
- Jobbigt att snabbt reseta upplevelsen för en ny delatagare, att försätta sig i en neutralt läge. Vart tvungen att starta om hela tiden The Lab för jämn introducerande upplevelse, speciellt om man var inne i ett aktivt spel. Svårt att ta sig ut ur ett spel till den "neutrala miljön" dvs hitta globen man lägger på sig.
- Samtliga delatagare "pustade ut" efter att man tog av sig HMD, ofta med ett oj eller med vad tråkig verkligheten blev nu. En kontrast mellan VR och IRL. Ofta rörde och justerade ögonen till att komma tillbaka till verkligheten.
- Alla älskade hunden, och vill klappa och leka med den: "Bli inte fäst emotionellt vid hunden nu Jossan"
- Deltagarna uttryckte att det var "mycket mer verkligt än man hade trott"
- "Lite läskigt innan, men sen när man kom in kom man över det snabbt". Samma deltagare som sa att hunden var väldigt snäll att ha. Blev märkbart mer avslappnad när hunden kom in i bilden.
- "När man tappade hörlurarna försvann en del av upplevelsen, man tappade instängdheten lite"
- ..men oavsett "Det känns ju inte som en riktig värld"
- "Man får hålla tillbaka vissa impulser, att man kan luta sig mot ett bord eller röra sig snabbt. Men nu var jag ju medveten"
- "Det tog emot att gå igenom den där grejen jag gick igenom ni vet" refererar til ett objekt i ett spel som deltagaren passerad igeonom.
- "Man behöver göra mer grejer man kan göra i den riktigt världen..." refererar till att kunna springa och röra sig fritt utan att kunna gå in i saker
- "...Men man behöver kanske inte kunna göra alla grejer man kan göra i den riktigt världen"
- Angående ljudet: "Kände mig i världen ändå även fast det inte var något ljud, [...] men det beror nog på upplevelsen hur viktigt ljudet är"
- Deltagare som plötsligt krockar med ett bord, skriker högt och blir skakade/rädd] "Men ni måste ju säga till att det är riska att jag går in i saker, jag visste ju inte att den var där!"
- "Pilbågen behövde man inte ljud för, vibrationen tillräcklig även och det kanske inte kändes exakt som en pilbåde vid eftertanke"
- Alla går in i saker och väggar, ofta och mycket
- Snubblar på sladden och måste kontinuerligt bli påminda om sladdan och risken att gå in i saker
- Svårt att förstå hur gränserna av rummet fungerar, och att få en överblick snabbt över hur man befinner sig i studen i relation till de yttre gränserna.
- Deltagarna uppfattar inte den delen av gränssnittet som ska säga vart gränserna går tillräckligt ofta. Svårt att förstå hur gränserna av rummet fungerar
- Det tar ett tag för deltagarna att vänja sig vid konceptet ch förstå vad man ska göra och allmänt hitta i världen och förstå hur allt hänger ihop, etc.
- Det är meckigt för alla att få på sig HMD, hörlurar och kontrollers med stropp, får hjälp.
- Hörlurarna ramlar ut
- Svårt att förstå kontrollerna
- Ofta mycket Wow-känsla så fort den initiala konfundering överkommits
- "Hur kan man någonsin spela som vanligt när man gjort VR?"
- "Alla spel i framtiden kommer ju vara VR!"
- "Fick lite nostalgi till när man testade Wii första gången, liksom wooooow!"
- Alla gillar hunden väldigt mycket
- Första deltagaren ut som testar och tidigt in i upplevelsen (vet om att det hadlar om fötterna, och sa något i stil med "okej nu ska jag tänka på hur det känns för fötterna"): "Vänta, här borde jag känt något med fötterna!" Glömmer snabbt bort agendan med att tänka på fötternas intryck dock pga allt annat som upplevs.
- Alla deltagare uttrycker att det känns svårt att brainstorma kring ämnet fothaptik.
- I efterhand: "Sjukt att intryck inte fanns"

Appendix 6

VERE code of conduct for the ethical use of VR in research and by the general public of Madary and Metzinger.

RECOMMENDATIONS FOR THE RESEARCH ETHICS OF VR

1. **Non-maleficence**
   a. No experiment should be conducted using virtual reality with the foreseeable consequence that it will cause involuntary suffering or serious or lasting harm to a subject.
   b. A rational, evidence-based identification and minimization of risks (also those pertaining to a more distant future) ought to be a part of research itself.
2. **Informed consent**
   a. Informed consent for VR experiments ought to include an explicit statement to the effect that immersive VR can have lasting behavioral influences on subjects, and that some of these risks may be presently unknown.
   b. Experimental VR research should not be carried out on subjects incapable of informed consent.
3. **Transparency and media ethics**
   a. In experimental work developing new clinical applications, researchers should be careful not to create false hopes in patients by repeatedly reminding them of the merely experimental nature of the research.
   b. VR researchers aiming at new clinical applications should work in close collaboration with physicians who may be better situated to make informed judgments about the suitability of particular patients for new trials.
   c. Scientists and the media need to be clear and honest with the public about scientific progress, and not only in the area of using VR for medical treatment.
   d. In interacting with the media, scientists should cultivate a proactive attitude, especially if they are the first to become aware of novel types of risks through their own work. Communication with the public, if needed, should be self-initiated, an act of taking control and acting in advance of a future situation, rather than just reacting.
4. **Dual use**
   a. Potential military applications of VR, AR, and SR should be closely monitored by policy makers and funding agencies alike.
   b. Torture in a virtual environment is still torture. The fact that one's suffering occurs while one is immersed in a virtual environment does not mitigate the suffering itself.
   c. Policy makers should aim at international arrangements among countries to add VR, AR, and SR in a process to harmonize lists of dual-use technologies to be controlled.
5. **Internet research**
   a. The scientific community has to take steps to avoid the abuse of informed consent with this technology, especially in the interest of preserving public trust.
   b. The ability to toggle between VR, AR, and SR may create situations in which users are not able to maintain an understanding of when their informed consent to share information is in effect. Users should be repeatedly reminded within VR that they have given informed consent.
6. **The Limitations of a Code of Conduct**
   a. Scientists must understand that following a code of ethics is not the same as *being* ethical. A domain-specific ethics code, however consistent, developed, and fine-grained future versions of it may be, can never function as a substitute for ethical reasoning itself.
   b. Such reasoning must be conducted in a way that is sensitive to the contextual and implementational details of particular experimental paradigms, details that cannot be captured by a general code of conduct.

RECOMMENDATIONS FOR THE USE OF VR BY THE GENERAL PUBLIC

1. **Long-term immersion**
   a. Longitudinal studies and further research into the psychological effects of long-term immersion are needed.
   b. Users must be made aware that these studies are seriously limited in that they will, due to ethical constraints, exclude users who may be most vulnerable (such as children or those with latent mental illness). Some of these vulnerabilities may be unknown to science and unknown to the users themselves.
2. **Increasing virtualization of social interactions – we call for focused research, large longitudinal studies, into the following questions:**
   a. What, if anything, is lost in cases of social interactions that are mediated using advanced telepresence in VR?
   b. If such losses were unnoticed, what negative effects for the human self-model could be expected?
3. **Risky content**
   a. As compared to the viewing of traditional movies containing graphic violence or pornography, the impact of full immersion settings and the associated risk of users suffering psychological trauma will steadily increase as VR technology advances. Users have to be made aware of this possibility.
   b. VR technology holds the potential to create robust social hallucinations, to directly manipulate the sense of agency, to modulate personality traits via identification with virtual characters, or to causally interact with deeper levels of self-consciousness (UI-manipulation). Users have to be made aware of this possibility.
   c. Avatar ownership will be an important issue for regulatory agencies to consider. There are strong reasons to place restrictions on the way in which avatars can be used, such as protecting the interests and privacy of individuals who strongly identify with their own particular avatar on social networks. On the other hand, these restrictions may prove impractical to implement and may unnecessarily limit personal creative freedom. Regulators must strike a rational balance between these concerns.
4. **Privacy**
   a. Users ought to be made aware that there is evidence that advertising tactics using embodiment technology, such as VR, can have a powerful unconscious influence on behavior. For example, a combination of "Big Nudging" strategies (collecting big data for the purposes of nudging the general public) with VR technology could have long-lasting effects, which might also affect underlying mental mechanisms themselves.
   b. Data protection: users ought to be made aware of new risks involving surveillance, such as reading out "motor intentions" or a "kinematic fingerprint" during avatar use.

Appendix 7

Design of survey directed to the current users

Survey about the use of Virtual Reality

This survey is part of a master thesis project about Virtual Reality (VR), of Industrial Design Engineering at Chalmers University of Technology.

The survey directs to individuals who currently own or work with VR equipment. Furthermore this survey is about your experiences and thoughts about being in VR, as well as haptic feedback in this medium. Haptics refers to the human sense of touch and our ability to perceive pressure and motion. This means e.g. vibrations, speed and surface structures. You may or may not have experience this when earlier using VR.

Accepted language for answering is Swedish or English. The survey is anonymous.

*Obligatorisk

About you

1. **Age** *

2. **Nationality** *

3. **Occupation** *

4. **Interests** *

5. **Which VR equipment do you have?** *
Markera alla som gäller.
- [ ] HTC Vive
- [ ] Oculus Rift
- [ ] Playstation VR
- [ ] Samsung Gear VR
- [ ] Google Daydream
- [ ] Google Cardboard
- [ ] Övrigt:

General questions about VR

6. **Why did you get your VR equipment?** *

7. **Which experience do you frequently return to when you are using VR? Why?** *

8. **Is there anything which you get annoyed over when in VR experiences? Why?** *

9. **Have you experienced any side effects after or during VR use?** *
Markera alla som gäller.
- [ ] Motion sickness
- [ ] Eye strain
- [ ] Dizziness
- [ ] Seizures
- [ ] Trouble with hand and eye coordination
- [ ] I do not know
- [ ] Never experienced any side effects
- [ ] Övrigt:

VR experiences and emotional response

The following questions will ask for your emotional response to some VR cases. When asked for, pick an emoji which you think most accurate describes your emotions.

10. **What did or do you feel about VR...** *

Markera endast en oval per rad.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
When you first heard about VR?														
When you first tested VR?														
When you got your VR equipment ?														
Right now?														
What do you think you will feel about VR in the future?														

11. **Which emoji most accurate describes how you feel when entering a new VR experience?** *

Markera endast en oval per rad.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pick a emoji number														

12. **Can you describe any blunders you have done in VR? Blunder refers to e.g. trying to lean on virtual objects which are not there, or trying to touch virtual things when you in reality know you can not.** *

13. **How did you feel when you learned that you made this blunder?** *

Markera endast en oval per rad.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pick a emoji number														

14. **Which emoji best describes in general what a VR experience feels like to you, that by the makers of this experience is supposed to be perceived as...** *

Markera endast en oval per rad.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Amazing														
Exciting														
Realistic														
Educational														
Useful														
Amusing														
Thrilling														
Scary														

VR and haptic feedback

Haptics means the sense of touch and the ability to perceive pressure and motion e.g. vibrations, speed and surface structures.

15. **Has there been cases when you have been missing some kind of haptic feedback in VR experiences? Which and how?** *

16. **Are there any cases when you think haptic feedback could be annoying or irrelevant? Which and how?** *

17. **Are there any cases when you think you would percieve haptic feedback as unpleasant? Which and how?** *

About future use and expectations of VR

18. **Would you like to have additional VR accessories to your VR equipment which could enhance the experience?** *
Markera endast en oval.

- Yes
- No
- Maybe

19. **How much money do you find reasonable to spend on such a product?** *
Markera endast en oval per rad.

	0-20	20-50	50-100	100-200	200+
Price in USD					

20. **If you could change anything about VR as it is right now, what would you change? Why?** *

21. **Is there anything about the future VR use which you feel critical about? Why?** *

22. **Is there anything about the future VR use which you have high expectations on? Why?** *

23. **Would you like to be participate in further interviews about VR? Please add your e-mail and name below.**

Thanks for your participation!

Appendix 8

Results of survey directed to the current users

	Specifically targeted (8p)	Reddit (10p)	All (18p)
Age	23-44 years old	21-42 years old	21-44 years old Median: 29,5 Tv: 23 Vb: 24
Nationality	7 swedes, 1 dutch	5 americans, 2 british, 1 german, 1 greek, 1 swede	North Americans and Europeans
Occupation	Software Developer VR Software engineer System Developer Programming, Audio Engineer Full time job Student Scientist Engineer	3 visual designers (2 in tech) 4 working with tech of some kinds 3 students	Very technically experienced individuals Educated
Interests	Programming, Music, VR, Games Computer graphics, electronics Dnd, Games, whisky Music, Games, Creating things VR/AR, Games, Film Unclear question Art, VR, Technology, Science, Biology Robotics, 3D-printing, VR	Hiking, Photography, PC Gaming VR :) Fantasy worlds, computers, old video games VR, 3d graphics, games, etc. Programming Tech Art, Islam, Gaming Video games(Strategy, rhythm and puzzle mostly) Computers, Video Games, Movies, Books. computers, martial arts, snowboarding, gaming, outdoorlife	Various technically oriented interests: IIIIIIIIIII 12p Games: IIIIIIIIII 11p VR and co: IIIIII 6p Computers: IIIIIIIII 9p
VR equipment	Google Cardboard 5 Oculus Rift 4 Playstation VR 3 HTC Vive 2 Others 2 (unspecified) Google Daydream 1 Samsung Gear VR 0	Biased due to which subreddits published in. Oculus Rift 8 Google Cardboard 3 Google Daydream 0 Others 1	8/18 has Google Cardboard (Then: Oculus Rift, HTC Vive or Playstation)
Why did you get your VR equipment?	To play games and develop open drivers. I am using it at work No reason in particular For creating VR applications and games, and to work on improving Linux support I work with visualization. We're branching off towards VR/AR. Curiosity I had tried many VR HDM as a researcher and fell in love with VR and its immersive worlds but couldn't afford any of the HDM (30 000 Kr + computer back in the day). And by the time the more affordable ones came out my Children were taking up too much space so I opted for a PSVR which isn't the greatest but does the job of letting me visit immersive Worlds. Wanted to try it out.	Entertainment April 2016 development Because VR is awesome. To play and make VR games. Enter a different reality/Immersion I believed the hype. Mostly worth it. Purchsed from oculus.com It was a Christmas gift. Experimentations on limitations for work related projects	Experiment, create for (and work) = 9 Games: 2 + 4 = 4 Test it out = 2 + 1 = 3 (Cool tech = 0 + 2)

Which experience do you frequently return to when you are using VR? Why?	Haven't found anything. Google Tiltbrush. It is fun and it is a good first experience when introducing people that have not tried VR before Shooters (bullet train), porn Mostly self made things, but I like The Lab as a funny showcase to sometimes spend some time in, Studying their implementations. Rec Room and Tilt Brush, for the creative and social aspects. Chair in a room (Android). Core experience showcasing strengths of VR VR experiences and games that do not have too much motion e.g. VR World's Shark tank. Demoes, looking at virtual products.	Dead n Buried. Fun Dead and Buried, BAM - Bullets and More. I really enjoying playing them Audio shield. Highly repeatable and exciting. The Climb, Dead and Buried, Audioshield, VRchat. Superhot and Onward for gaming, Medium for creative outlets. Arizona Sunshine, Audioshield Social co-op adventuring or co-op horde modes are my favorites. Singleplayer adventure/action games are also of interest. Audioshield, I like rhythm games. H3VR. I find it satisfying to mess around with. The resolution is still too low which diminishes the immersion	Entertainment: 3+9=12 Showcasing and understand VR: 4+1=5 Create: 2+0=2 Social: 1+2=3
Is there anything which you get annoyed over when in VR experiences? Why?	That I get sick. Motion sickness and low framerate. It does not feel comfortable Lack of good titles Narrow FoV is the main thing that bothers me, also lack of CV1 - Never ending tracking issues HTC Vive - Connection issues, Cable management GearVR - Phone overheating Basically, anything that disrupts the "on demand" way we consume media today. Clunky interactions. Control methods are still too clunky to be really immersive Bad Graphics and tracking (as in the case of PSVR) Don't have devices with headtracking, getting a bit of nausea.	Cable, Tracking Issues, Lens Fogging, VR Motion sickness God rays - They make me feel like im getting a migraine until they go. how underdeveloped most tutorials are. People who have headsets with crappy mics. None so far. Tracking issues, resolution, lens quality Comfort, weight, fit, heat/sweat, lens adjustment, FOV, blurry text/picture. Performance/Tracking issues, small text When tracking is lost or becomes strange on the hands or headset. It's either frustrating or disorienting. The pricing of the gear and the nausea/headache associated with longer sessions	Quality of technology-related aspects which disturbs interaction: 4+6=10 In specific tracking: 3+4=7 Motion sickness: 3+1=4 Headache: 0+2=2 Content (quality): 1+1=2 Interaction aspects mentioned: - HMD comfort/fit/sweat/heat - The Cable - Clunky control methods - Lens fogging - Crappy mics (-The pricing)
Have you experienced any side effects after or during VR use?	Has experienced: 7 Additional: nightmares	Has experienced: 10 Additional: headache “At first, when I was still new to VR and was spending a lot of time in it, whenever I left the headset I would feel like I hadn't really returned to reality. I'd sometimes reach for controls or gestures from the games or just sit there feeling a4s if the world were strangely fake. Eventually this went away.”	Motion sickness: 5+8=13 Eye strain: 3+5=8 Dizziness: 0+4=4 Other: 2+3=5 Hand/eye coord.: 0+1=1
Can you describe any blunders you have done in VR)	Nothing I can remember. I accidentally hit someone that was walking close to me while I was in VR Hit the wall once with my hand, that's about it.	trying to touch virtual things, trying avoid objects I was playing table tennis and tried to lean on the table to reach the ball, the table did not exist! I walk into my walls pretty frequently	Hitting things and getting hurt/hurting someone or something: 5+4=9 Balance related things during rollercoasters: 1+1=2

	Hitting a lamp, don't play VR in a room with a hanging lamp. I've run into walls, tried to lean on objects, punched a TV with the controllers. You don't think it will, but sooner or later, you will be immersed enough to forget. Tried to lean on desk in Job Simulator I destroyed a lamp When trying roller coasters, it can be a bit hard to keep balance.	Punched the ceiling a couple of times due to there being no guardian boundary there. I hit my head on my desk reaching for something, and also regularly hit my ceiling. (I'm tall) None Docked when something flew at me. Trying to pick up objects that are not movable, touching my controllers together to look at how accurate the in game model represents the real controller position. I turned off the guardian boundary settings for a sit-down experience and forgot to re-enable them for H3VR, because of this I slammed my arm into my desk while playing grenade skiball and gave myself a bad bruise. I've experienced almost falling of a chair while on VR rollercoaster :)	Trying to lean on or touch or avoid things that aren't there: 2+4=6
How did you feel when you learned that you made this blunder?	*	*	:P = 6 *thinker* = 4 Slightly negative in relation to earlier results
Which emoji best describes in general what a VR experience feels like to you, that by the makers of this experience is supposed to be perceived as...	**	**	In general, everything is described with emojis describing very positive or positive experiences, with interesting aspects to it.
Amazing	++	++	
Exciting	++	++	
Realistic	+	+++ till 0	
Educational	+ -> 0	0 -> +	
Useful	0	+	
Amusing	+	++	
Thrilling	+	++	
Scary	+	+	
Has there been cases when you have been missing some kind of haptic feedback in VR experiences? Which and how?	Sure, being able to touch stuff would be awesome. How, well there's the kicker... In some experiences it would be nice if you could get haptic feedback if you are touching a wall or similar. It is quite confusing when you can't feel or touch the objects that you are interacting with. All the time Feeling weight of objects is the main thing, which is hard to simulate in current setups No -	No No no. My mind understands vibrations from years of video games. No. I want stronger haptic feedback when shooting guns. Noi All the time. Even the basic actions of picking something up can have no feedback in my VR games.	Yes: 5+5=10 No: 1+5=6 It's important to have For the sake of sensation or gaming

	Yes, when I touch an object and the Control doesn't Buzz is an immersion killer Roller coasters and similar in VR can be a bit tricky, since the movements are not represented.	Audioshield, haptic feedback only worked/works with SteamVR beta Mostly in Steam VR games that don't directly support the Oculus SDK like H3VR. There's just genuinely nothing there. In the DK1 the response of headmovement was missing which gave a really weird feeling since you felt "free but stiff"	
Are there any cases when you think haptic feedback could be annoying or irrelevant? Which and how?	Don't know. I think it could be annoying if you play a shooter game and actually feel when you are being hit by the opponent. It would probably be quite annoying in any multiplayer VR experience, if other people could make you feel things as a result of their actions. People could abuse that feature, just to annoy you. Not sure overusing when available, gimmicky Haptic feedback is useless while working with windows on your desktop, and it will also be useless in most contexts in VR. - Not that I have come across I don´t think a lot of feedback is required to create a realistic feeling.	No No No Only when it's not user configurable I'm sure if they tried, someone could make haptic feedback annoying? Maybe when working in Medium, doing really repetitive tasks. Feedback used to simulate weight seems irrelevant with current tech. Maybe you could say haptics as an indicator you've been hit when really it was your body versus the hands were the controllers currently product haptic feedback. Whenever it is not in response to a virtual object interacting with the user's hand or user input. When it's constant and or high it can be difficult to tell what's causing it or what it's supposed to mean. I think its a really elementary part of VR and I can only see it being negative if its inproperly implemented	No/don't know: 5+3=8 Overuse: 2+4=6 Not having thought it through: 2+6=8 Annoying in interactions with others Irrelevant things simulated or not good enough
Are there any cases when you think you would perceive haptic feedback as unpleasant? Which and how?	Don't know. Same as the previous answer if the haptic feedback is to strong. Not sure above reason Tricky question to answer. I can think of many case specific scenarios, but nothing general. Unpleasant doesn't mean it's not a useful - even important - part of an experience. - If I was stabbing someone, in those instances I would prefer it to be as little realism as possible No	No No No Only when it's not user configurable Cant think of any. No, it really enhances the experience. Need more haptics Maybe if it's a very violent game and haptics can simulator the pain like a horror or torture game. ABE VR comes to mind. When I don't know what is causing it. Sound cues synced tot he haptics could help with this in some cases. Only if it were constant and on a high setting for an extended period of time. Maybe when stopping or starting in a simulation. Like maybe stopping in a car or spaceship.	Abusing and overusing it Unpleasant might also be useful Not knowing what is causing it Violence:1+1 No/don't know: 4+5=9

Would you like to have additional VR accessories to your VR equipment which could enhance the experience?	Yes	Yes	YES
How much money do you find reasonable to spend on such a product?	20-50 to 200+	20-50 to 200+	Median: 50-100 Tv: 50-100
If you could change anything about VR as it is right now, what would you change? Why?	No non-1:1 movement whatsoever. Possibly an exception for cockpit games. Higher resolution, because I think at least 4k resolution for each eye would be ideal. Bigger room size, because I think that the room size is a limiting factor in many VR experiences on the HTC Vive. . Have developers create less demanding games by using older optimized rendering techniques and assets/style, lower entry cost, better multi-platform and hardware agnostic support. Disregarding the most obvious problems with VR-tech today, I think the optics, i.e the bulkiness of HMD's, is the real culprit. I think Near Eye Lightfield Displays is the next big revolution in wearables. Standardize control methods and software platforms Better tracking More content, perhaps social.	Wireless Less god rays, no cables, cooler headset Lower the price of vr hardware and high end PC hardware. Higher resolution screens, lighter headsets, wireless. More AAA games. Haptic vests, the glove controls that are coming out, maybe an outward camera so you could do augmented reality while wearing the headset. Resolution, Room-scale, and hardware I would want a much larger FOV because I think even with the current strap system and weight it would immerse me more in the experience. getting rid of the cable to the HMD, it really gets in the way when playing anything where you are moving around the room. Proper cable management can improove this somewhat, but a well working wireless headset would be better. I would love to get rid of the screen door effect, just for better clarity. I would also try to lower costs to expand the user base. A way of moving in 3d-space without the need of a giant room.	Technical improvements: 4+4=8 Better experience design related changes: 5+10=15 No cable and better headset design: 1+5=6 Price: 1+2=3 Move around more freely without having to bump into things/the room size issue: 2+2=4 Standardize controls and platforms Social experiences No god rays (ljuskäglor) Content quality Outward camera, AR Haptic vests+gloves
Is there anything about the future VR use which you feel critical about? Why?	Don't know. Currently I am not aware of any killer apps. I don't know of any apps or games that is so good that it would motivate me to buy VR equipment to use at home. . Hardware lockdown of applications and games., bad for users. Near Eye Light Field Displays - Reduce the bulkyness of the HMD. Eye Tracking - Push more pixels with less processing/battery/heat. Critical for wearable tech. A new standardized input ("keyboard & mouse" for VR) - Critical for obvious reasons. Accessibility for people with hearing/vision impairment and lost limbs.	Education, Business, Web Wireless, wider view, higher resolution people not making good experiences and souring the market. No. The expense excludes mass adaptation, so costs really need to come down to keep fueling advancement in it. No Being cut off from the others in the house. The trend towards less sit-down type experiences. Standing and walking is cool, but it gets exhausting and I feel like the "killer app" needs to be something where you can sit, just so people can actually play it comfortably for long periods of time.	Technical quality stuff needs to be improved: 2+1=3 Experience stuff (needs to be improved): 6+6=12 The content quality or "bad" content: 2+4=6 The matrix/being cut off from reality: 1+1=2 The price Accessibility Standardization Haptics User embodiment in an acceptable way Its exhausting to stand up

	Many of the experiences are from either gender neutral or male persective. To embody my own cognition I would like to look down and see a female body once in a while. The Matrix.	The industry's insistence on unified movement and control paradigms for VR games may land up hurting more than helping. Not every game is Onward or The Lab, and I think more games should be open to finding control schemes that better meet their needs. Implementing gear that allows you to feel and touch surfaces	
Is there anything about the future VR use which you have high expectations on? Why?	Mixed reality and telecommuting, because it will change the way we live our daily lives, and where we live them. (Deurbanization?) I would like to try a VR experience like "The Void". https://virtualrealityreporter.com/the-void-virtual-reality-physical-gaming/ It is only available in the US at the moment. Also I have high expectations on the next generations of VR hardware like HTC Vive 2 for example. . Implementation of higher FoV displays and/or use of indirect projection (projecting on the retina instead of looking through lenses). Eye Tracking. It's near future tech, critical for battery life/heat/processing, and the stuff I've tried is amazing. Great tool for teaching empathy and potential to increase productivity No Porn	Social better quality, wider view. I try not to have high expectations. Looking forward to some of those ~$300m games getting VR support. Social aspects. No Comfort. It needs to improve. Controlling the vestibular system, like GVS. I get sick very quickly from regular locomotion or flipping upside down in an aircraft in VR for example, but in real life I can ride roller coasters without getting sick at all. I hope that once we can reliably control which direction is the percieved up-direction to the user, flight and space sims will get a lot more comfortable. Wireless, as the cables are annoying and possibly a bit dangerous. Removing a tripping hazard should make Roomscale VR much more viable. allowing people to explore imaginative worlds and understanding that our world doesnt have to be a limitation.	Futurism: 1+1=2 Fuller immersions (like the void): 3+1=4 Technical improvements: 3+3=6 Experience improvements: 3+7=10 Social: 0+2=2 Related to comfort: 1+2=3 Learn empathy Porn Really good games Not feeling sick Explore things Wireless

***UX-curve analysis**

1. **first time heard about VR**
2. **first time tested VR**
3. **when you got VR**
4. **entering an experience**
5. **when you have made a blunder**
6. **now**
7. **think you will feel in the future**

Targeted:

1. 11111355 -> Median=1, Tv=1, Vb=5-1=4 -> **1**
2. 12223558 -> Median=2,5, Tv=2, Vb=8-1=7 -> **2**
3. 11222447 -> Median=2, Tv=2, Vb=7-1=6 -> **2**
4. 12345677 -> Median=4,5, Tv=7, Vb=7-1=6 -> **4**
5. 13377811112 -> Median=7, Tv=3&7, Vb=12-1=11 -> **7**
6. 11224446 -> Median=3, Tv=4, Vb=6-1=5 -> **4**
7. 11133347 -> Median=3, Tv=1&3, Vb=7-1=6 -> **2**

Reddit:

1. 11111111478 -> Median=1, Tv=1, Vb=8-1=7 -> **1**
2. 11111111125 -> Median=1, Tv=1, Vb=5-1=4 -> **1**
3. 11111111337 -> Median=1, Tv=1, Vb=7-1=6 -> **1**
4. 11222333344 -> Median=2,5, Tv2&3, Vb=4-1=3 -> **3**
5. 13333577913 -> Median=4, Tv=3, Vb=13-1=12 -> **5**
   (pga. Att hälften sa saker som kändes direkt negativt)
6. 11122444677 -> Median=3, Tv=1, Vb=7-1=6 -> **3**
7. 11111111127 -> Median=1, Tv=1, Vb=7-1=6 -> **1**

Average:

1. 111111111 1 111345578 -> Median=1, Tv=1, Vb=8-1=7 -> 1
2. 111111111 1 222235558 -> Median=1,5, Tv=1, Vb=8-1=7 -> 1,5
3. 111111111 1 22334477 -> Median=1,5, Tv=1, Vb=7-1=6 -> 2
4. 111222233 3 34445677 -> Median=3, Tv=2&3, Vb=7-1=6 -> 3
5. 113333335 7 77789 11 12 13 -> Median=6, Tv=3, Vb=9-1 -> 6
6. 111112222 4 44446677 -> Median=3, Tv=1&5, Vb=7-1 -> 4
7. 111111111 1 12333477 -> Median=1, Tv=1, Vb=7-1 -> 1

****Emotional matching analysis – What does experiences feel like to you that are supposed to be….**

1. **Amazing**
2. **Exciting**
3. **Realistic**
4. **Educational**
5. **Useful**
6. **Amusing**
7. **Thrilling**
8. **Scary**

Targeted:

1. 13344451<u>0</u>, Median=4, Tv=4, Vb=10-1=9 -> 4
2. 13344455, Median=4, Tv= 4, Vb=5-1=4 -> 4
3. 14444555, Median=4, Tv=4, Vb=5-1=4 -> 4
4. 12445579, Median=4,5, Tv=4/5, Vb=9-1=8 -> 4,5
5. 12355679, Median=5, Tv=5, Vb=9-1=8 -> 5
6. 12344457, Median=4, Tv=4, Vb=7-1=6 -> 4
7. 12334456, Median=3,5, Tv=3/4, Vb=6-1=5 -> 3,5
8. 123556711, Median=5, Tv=5, Vb=11-1=10 -> 5

Reddit:

1. 1112234456, Median=2,5, Tv=1, Vb=6-1=5 -> 2
2. 1111112344, Median=1, Tv=1, Vb=4-1=3 -> 1
3. 1113445688, Median=4, Tv=1, Vb=8-1=7 -> 4
4. 1124777889, Median=7, Tv=7, Vb=9-1=8 -> 7
5. 1123344479, Median=3,5, Tv=4, Vb=9-1=8 -> 4
6. 1111122344, Median=1,5, Tv=1, Vb=4-1=3 -> 1
7. 1111112477, Median=1, Tv=1, Vb=7-1=6 -> 1
8. 1111118<u>10 11 11,</u> Median=1, Tv=1, Vb=11-1=10 -> 1

Average:

1. Amazing: 1111223334444455<u>10</u>, Median=3,5, Tv=4, Vb=10-1=9 -> 3,5
2. Exciting: 111111123334444455, Median=3, Tv=1, Vb=5-1=4 -> 3
3. Realistic: 11113444445555688, Median=4, Tv=4, Vb=8-1=7 -> 4
4. Educational: 11122444557778899, Median=5, Tv=7, Vb=9-1=8 -> 7
5. Useful: 111223334445567799, Median=4, Tv=1/3/4, Vb=9-1=8 -> 4
6. Amusing: 1111112223334444457, Median=2,5, Tv=1, Vb=7-1=6 -> 2
7. Thrilling: 11111112233445677, Median=2,5, Tv=1, Vb=7-1=6 -> 2,5
8. Scary: 1111111235567<u>810 11 11 11</u>, Median=4, Tv=1, Vb11-1=10 -> 3

Appendix 9

Design of survey directed to the potential users

Survey regarding Virtual Reality

This survey is part of a master thesis project about experience design in Virtual Reality (VR), of Industrial Design Engineering at Chalmers University of Technology together with DigitasLBi.

VR means using a head mounted display to simulate any virtual world and experiences. Due to the possibilities given by this technology, it is thought that we perceive virtual worlds in similar manners as we perceive the real world. Therefore, this survey is not only about VR in particular, but also about what creates certain real world experiences. Answer the following questions as accurate as possible according to your own experiences and opinions.

Accepted language for answering is Swedish or English. The survey is anonymous.

*Obligatorisk

About you

1. **Age** *

2. **Nationality** *

3. **Occupation** *

4. **Interests** *

5. **Rate approximately how much time you spend with these screen technologies in your everyday life.** *
Markera endast en oval per rad.

	0 h	<1 h	1-2 h	2-3 h	3-4 h	4-5 h	5-6 h	6+ h
TV	◯	◯	◯	◯	◯	◯	◯	◯
Smartphone	◯	◯	◯	◯	◯	◯	◯	◯
Professional smartphone	◯	◯	◯	◯	◯	◯	◯	◯
Laptop	◯	◯	◯	◯	◯	◯	◯	◯
Professional laptop	◯	◯	◯	◯	◯	◯	◯	◯
PC	◯	◯	◯	◯	◯	◯	◯	◯
Professional PC	◯	◯	◯	◯	◯	◯	◯	◯
Tablet	◯	◯	◯	◯	◯	◯	◯	◯
Professional tablet	◯	◯	◯	◯	◯	◯	◯	◯
Other screen technology	◯	◯	◯	◯	◯	◯	◯	◯

About VR

6. **Have you heard about VR before this survey?** *
Markera endast en oval.
- ◯ Yes
- ◯ No

7. **How many times have you tried VR?** *
Markera endast en oval.
- ◯ I have not tried it
- ◯ 1-2 times
- ◯ 3-5 times
- ◯ 6-9 times
- ◯ 10 + times

8. **If you have not tried VR before, would you like to try it?** *
Markera endast en oval.
- ◯ Yes
- ◯ No
- ◯ I have tried it

9. **How do you feel about VR? Pick the emoji that describes your feelings best.** *

1 2 3 4 5 6 7 8 9 10 11 12 13 14

Markera endast en oval per rad.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pick an emoji number	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

10. **Why do you feel this way about VR?** *

11. **If you were to use VR, in what context would you feel comfortable/uncomfortable when using it?** *
Markera endast en oval per rad.

	Comfortable	Uncomfortable
Alone	◯	◯
With family	◯	◯
With friends	◯	◯
With colleagues	◯	◯
With strangers	◯	◯

12. **Which of these use areas do you think that you would be most interested in using VR for?** *
Markera alla som gäller.
- ☐ Entertainment
- ☐ Work out and well-ness
- ☐ Education
- ☐ Travelling
- ☐ Social functions
- ☐ Shopping and other consumer activities
- ☐ Real-estate previews
- ☐ Healthcare, therapy and rehab
- ☐ Business, science and industry
- ☐ Övrigt:

13. **What are your expectations on the future role of VR?** *

Real life experiences

When creating experiences for VR it is important to know how people perceive various situations in real life. Therefore, the following section is about what characterizes different situations of yours in real life.

14. **Describe a situation in real life when you feel confident?** *

15. **Describe a situation in real life when you feel unconfident?** *

16. **Describe a situation in real life when you feel relaxed?** *

17. **Describe a situation in real life when you feel stressed?** *

18. **Describe a situation in real life when you feel happy?** *

19. **Describe a situation in real life when you feel scared?** *

Experiences of the feet

The last section will treat experiences given from your feet. Why the feet? For the most part of the time your feet are in contact with your surrounding world, providing you with information about the properties of your surroundings. This means that the feet play an important role in any natural or virtual reality for it to make sense.

20. **Are there any feet experiences which you find unpleasant? Why?** *

21. **Are there any feet experiences which you find pleasant? Why?** *

22. **Are there any experiences to your feet that you usually avoid? Why?** *

23. **Approximately, how much time per day do you spend on your feet? (Standing up, walking and running)** *
Markera endast en oval.

- <1 h
- 1-2 h
- 2-3 h
- 3-4 h
- 4-5 h
- 5-6 h
- 6-7 h
- 7+ h

24. **How much time would you like to spend on your feet? (Standing up, walking and running)** *
Markera endast en oval.

- <1 h
- 1-2 h
- 2-3 h
- 3-4 h
- 4-5 h
- 5-6 h
- 6-7 h
- 7+ h

25. **Draw to mind a case where you used your feet to investigate an object or ground surface. What was it and why did you do it?** *

Thank you for your participation!

Appendix 10

Results of survey directed to the potential users

	Social media (25p)	DLBi office (16p)	All (41p) + Analysis
Age	21, 23, 23, 23, 23, 24, 24, 24, 24, 24, 25, 25, 25, 25, 26, 26, 27, 28, 29, 30, 32, 41, 48, 63 Median = 25 y Mode = 24&25 y Variation width = 42 y	27, 28, 28, 28, 29, 29, 30, 30, 30, 31, 32, 38, 44, 46, 52, 200 (void) Median = 30 y Mode = 28&30 y Variation width = 25 y	21, 23, 23, 23, 23, 24, 24, 24, 24, 24, 25, 25, 25, 25, 25, 26, 26, 27, 27, 28, 28, 28, 28, 29, 29, 29, 30, 30, 30, 30, 31, 32, 32, 38, 41, 44, 46, 48, 52, 63, 200 (void) Median = 28 y Mode = 24&25 y Variation width = 42 y Primary the half of younger price sensitive target group was reached, but also some of the older target group. As the sample group was selected from social media and DigitasLBi's office, there is probably a bias in the answers. This might be specially for the older target group. However, as they are being urbans they could still be seen as representative as different kinds of office work is probably more common than others for 35-44 year old urbans.
Nationality	Swedish = 24 Spanish = 1	Swedish = 16	Swedish = 40 Spanish = 1
Occupation	Student = 15 = 60% Engineer = 2 = 8% UX designer = 2 = 8% Other = 6 = 24%: Farrier, consultant, coordinator, lab technician, civil servant, purchaser	Developer/IT = 6 = 37,5% Creative/UX = 5 = 31,25% Journalist/writer = 2 = 12,5% Project manager = 2 = 12,5% Strategist = 1= 6,25%	Studying are the greatest part of the responders occupation, having to do both with the reached sample group but also that many people tend to study while in their 20's, which furthermore is half of the target group. Some kind of higher education is also very common, which also has to due with the sample group reached. Following, technical occupations are common
Interests	All types of creative stuff/activities and being physically active (as in being outdoors, exercising etc.), being social and technology are interests of these. **Exercising, health, outdoors and sports = 12 = 48%** **Music = 11 = 44%** **Technology = 10 = 40%** **Other creativity oriented activities = 7 = 28%** **Design = 7 = 28%** **Family and social = 5 = 20%** Art and photo= 4 = 16% Games = 4 = 16% Food and cooking = 3 = 12% TV-series and movies = 3 =12% Fashion and decoration = 2 = 8% Home and garden activities = 2 =8% Travel = 2 = 8% Animals = 2 = 8% Politics and sustainability = 1 = 4% Books = 1 = 4%	Being physically active of any kind, and technology oriented activities. Gaming and entertainment in particular. **Exercising, health, outdoors and sport = 7 = 43,75%** **Technology, 3D and computers = 7 = 43,75%** **Gaming = 4 = 25%** **Film, TV and series = 4 = 25%** Food = 3 = 18,75% Music = 2 = 12,5% Writing = 2 = 12,5% Travel = 1 = 6,25% Philosophy = 1 = 6,25% Family = 1 = 6,25% Art & photography = 1 = 6,25% Indoor activities = 1= 6,25%	All types of being physically active (as in being outdoors, exercising etc.) but also creative activities. Different types of technology is also an interest, and also particularly gaming and other types of "technical" entertainment. Lastly, being social is also an interest.
Time spent with screen technologies			
TV	0h = 7 <1h = 5 1-2h = 7 2-3h = 1 3-4h = 4 4-5h = 0 5-6h = 0 6+h = 1 Median = 1-2h Mode = 0&1-2h	0h = 1 <1h = 8 1-2h = 5 2-3h = 2 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 0 Median = <1h Mode = <1h	

	Variance width = 6	Variance width = 2-3	
Smartphone	0h = 0 <1h = 1 1-2h = 9 2-3h = 10 3-4h = 3 4-5h = 0 5-6h = 0 6+h = 2 Median = 2-3h Mode = 2-3h Variance width = 5	0h = 2 <1h = 3 1-2h = 7 2-3h = 2 3-4h = 1 4-5h = 1 5-6h = 0 6+h = 0 Median = 1-2h Mode = 1-2h Variance width = 4-5	Long time daily! About 2 h
Professional smartphone	0h = 18 <1h = 5 1-2h = 1 2-3h = 0 3-4h = 1 4-5h = 0 5-6h = 0 6+h = 0 Median = 0h Mode = 0h Variance width = 3-4	0h = 4 <1h = 5 1-2h = 3 2-3h = 1 3-4h = 0 4-5h = 2 5-6h = 0 6+h = 1 Median = <1h Mode = <1h Variance width = 6	
Laptop	0h = 5 <1h = 3 1-2h = 4 2-3h = 2 3-4h = 1 4-5h = 2 5-6h = 4 6+h = 4 Median = 2-3h Mode = 0h Variance width = 6	0h = 4 <1h = 6 1-2h = 3 2-3h = 0 3-4h = 1 4-5h = 0 5-6h = 0 6+h = 2 Median = <1h Mode = <1h Variance width = 6	Long time daily if you are a student
Professional laptop	0h = 17 <1h = 0 1-2h = 2 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 1 6+h = 5 Median = 0h Mode = 0h Variance width = 6	0h = 2 <1h = 0 1-2h = 1 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 1 6+h = 12 Median = 6+h Mode = 6+h Variance width = 6	Long time daily if you are working
PC	0h = 13 <1h = 1 1-2h = 4 2-3h = 1 3-4h = 1 4-5h = 2 5-6h = 1 6+h = 2 Median = 0h Mode = 0h Variance width = 6	0h = 11 <1h = 1 1-2h = 1 2-3h = 1 3-4h = 1 4-5h = 0 5-6h = 0 6+h = 1 Median = 0h Mode = 0h Variance width = 6	
Professional PC	0h = 17 <1h = 0 1-2h = 1 2-3h = 2 3-4h = 0 4-5h = 1 5-6h = 2 6+h = 2 Median = 0h Mode = 0h Variance width = 6h	0h = 11 <1h = 1 1-2h = 0 2-3h = 0 3-4h = 0 4-5h = 1 5-6h = 0 6+h = 3 Median = 0h Mode = 0h Variance width = 6	
Tablet	0h = 14 <1h = 7 1-2h = 4 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 0 Median = 0h Mode = 0h Variance width = 1-2	0h = 10 <1h = 2 1-2h = 4 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 0 Median = 0h Mode = 0h Variance width = 1-2	

Professional tablet	0h = 23 <1h = 1 1-2h = 1 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 0 Median = 0h Mode = 0h Variance width = 1-2	0h = 13 <1h = 3 1-2h = 0 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 0 Median = 0h Mode = 0h Variance width = <1	
Other screen technologies	0h = 19 <1h = 3 1-2h = 1 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 2 Median = 0h Mode = 0h Variance width = 6	0h = 12 <1h = 3 1-2h = 1 2-3h = 0 3-4h = 0 4-5h = 0 5-6h = 0 6+h = 0 Median = 0h Mode = 0h Variance width = 1-2	
Sum up: -Most common used tech -Conclusion of adaption to tech according to time spent -What is used for profession vs private -If you use for private, what? -If you use for professional, what?	**-Overall most common used tech?** Laptop and smartphone (2-3h), followed by TV (1-2h). **-If you use for professional, what?** Over all, this sample group do not use professional screen tech, probably because they are in their 20s and students. However, those that are using for professional purposes uses 1. Prof. Laptop = 6h (median) 2. Prof. PC = ~5h (median) 3. Prof. Smartphone = <1h (median) **-What do you not use for professional?** Professional tablets are very rarely used at all for professional purposes. **-If you use for private, what?** Everyone is using a smartphone for some time during the day, where median time is 2-3h (40%). Some are using for a bit less time, some are using for al lot longer. After smartphone, the laptop is used for a median of 2-3 h (16%), however 5 (20%) does not use a laptop at all in their daily life, though the variance is big. The PC is not at all used by 13p (52%), though with a great variance. As for tablet, 14p (56%)are not using it, and those using it are using it for a median of <1h. This means that the use of smartphones is great, where everyone uses it, followed by laptops where some are however not using it at all. **-What do you not use for private?** The tablet is not used for that long of a time, but it is however longer used than for the professional case. **-Conclusion of adaption to tech according to time spent?** The smartphone is strongly used by everyone, followed by the laptop. When coming to professional cases the laptop is most frequently used but also the PC. Professional smartphones also used, however for very short time. It seems like for private purposes they use more mobile screen technologies, and for professional more stationary technologies. This means that the adaption to different types of screen technologies are great, where very few of these types are not known to this group. **-Which technologies do they own in combo?** Everyone uses a private smartphone, and very common a laptop in combination. The laptop they most likely own by themselves. In addition to the laptop, a tablet and PC might also be used. **-If they have a professional laptop to use, do they use a private one also?** Yes, but there are rare exceptions. **-Are there any technologies that are "the only screen" they use?** No.	**-Overall most common used tech?** Professional laptop (6+h) outranks all other by far, next is the smartphone (1-2h). **-If you use for professional, what?** The professional laptop is the most used screen technology over all. Except for the professional smartphone (<1h) other screen technologies for professional purposes are not used over all. However, a small group of this sample group uses professional PCs for a long time daily, which probably has to do with the IT/developer occupation orientation of the sample group. **-What do you not use for professional?** Professional tablets and PCs are very rarely used. **-If you use for private, what?** The smartphone is used for the longest time daily with median 1-2hs (43,75%). The group that does not use a private smartphone uses the professional smartphone as private. However there is a variance in the time. After the smartphone, the TV and laptop is used with median <1hs (50 % vs 37,5%). As for the laptop there is a big variance when it comes to the time. Other screen technologies are not used. **-What do you not use for private?** The tablet and PC is not used for private. **-Conclusion of adaption to tech according to time spent?** The smartphone is used by everyone, but the professional laptop is used for the longest time daily. Overall, mobile screen technologies solutions is used strongly. This does not have to mean that this group is not used to the other technologies which might be viewed as the "older v ones". Also 25% said that movies, TV and series are their interests, which indicates rather non-mobile screen technologies. However, the case could be that they are watching on their smartphones or laptop. So, this group is used to and has adapted to different types of screen technologies. **-Which technologies do they own in combo?** **-If they have a professional laptop to use, do they use a private one also?** **-Are there any technologies that are "the only screen" they use?**	The smartphone and laptop are most frequently used, where these screen technologies often are the private one, except for the laptop. The TV is also used and for some, a tablet are also present. However, by most is a tablet never used at all, which could be due to the smartphones concurring with the tablet. A PC might be used instead for a laptop, which seems to have to do with what you want to do with your computer, e.g gaming. Over all the smartphone is used by everyone. However there is always another screen technology present in combination with the smartphone. Most often this is a laptop. If you are working, you will be more likely to spend a lot of time with a professional laptop, and spend more time on the professional laptop than on any smartphone. If you are not working the smartphone will be where most time is put. What this means for this project is that the target group has great experience of different screen technologies and their corresponding languages of interaction. Furthermore, the users switch between these on a daily basis, meaning that they are controlling several languages of interaction simultaneously. Additionally, this could mean that the target group could be open to handle another language of communication, which the interaction model of VR will be. However, this will mean some time spent with adapting to this new interaction language, as it will probably differ a lot from how interaction is performer with current screen technologies. **Difference between younger target group and older target group?** The older age group spend more time with the TV than

			the younger target group does. Fewer of the older group spend 0 h than for the younger, but more of the younger spend longer times in front of the TV. Though the variation width is big for both. No one of the older group do not use a tablet for any time of the day. The younger uses the tablet more, though median and mode for these are still 0. There are similarities between the groups in that everyone uses the smartphone and laptop technology considerately more then the other screen technologies. Both age groups uses their smartphone for a median/mode of 2-3 hours a day. It is also similar between the age groups that the private laptop either is used little or a lot (as the modes). Regarding the professional laptop, the older group uses this one a lot (median and mode 6+hour), but the younger group does not use (median and mode 0 hours), which is probably due to the 20s being the student age.
About VR			
Have you heard about VR before this survey?	Yes (all)	Yes (all)	
How many times have you tried VR?	Never = 48% 1-2 times = 24% 3-5 times = 16% 6-9 times = 0% 10 + times = 12% Most have no experience at all, or very little experience with VR.	Never = 0 1-2 times = 18,8% 3-5 times = 31,3% 6-9 times = 31,3% 10 + times = 18,8% Most have little experience with VR, with a subset of individuals having used VR many times. This is due to the technical orientation of the group and that it is DigitasLBi employees.	As for the social media sample group most have no experience at all, or very little experience with VR. The sample group of the DigitasLBi office has more experience with VR, due to them having VR equipment available at their office. Therefore their experiences by VR might be seen as misrepresentative for the over all target group. Furthermore, the social media sample group's experience might be seen as more representative in terms of the VR experience.
If you have not tried VR before, would you like to try it?	100% yes of these.	100% has tried. This is due to the technical orientation of the group and that it is DigitasLBi employees.	There seem to be a interest in VR as everyone wants to test it.
How do you feel about VR? Pick the emoji that describes your feelings best.	2, 2, 2, 2, 3, 3, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5, 6, 6, 7, 7, 7, 8, 8 (+11) Median = 5 Mode = 4&5 (24% each) Variation width = 6	1, 1, 1, 1, 1, 2, 3, 3, 3, 3, 4, 4, 5, 5, 7, 7 Median = 3 (25%) Mode = 1 (31,25%) Variation width = 6	1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5, 5, 6, 6, 7, 7, 7, 7, 7, 8, 8 (+11) Median = 4 Mode = 4&5 Variation width = 7 Overall, positive emotions about VR are expressed, spanning for "Wow" to happy and esciting emotions when thinking of VR. Hoever, the DigitasLBi sample group is more positive in their emotions than the social media sample group generally is. This is

			probably due to that the DigitasLBi works with VR and has VR equipment available, which affects the answers. Therefore the social media sample group might be seen as more representative in general for this target group. A conclusion might however be drawn that the more experience one have with VR the more positive emotions might be expressed.
Why do you feel this way about VR?	it fun and interesting, but right now a bit too much hassle, and not prioritised from my side as it does nog give enough. Det har funnits bra länge redan. Bara att grafiken nu har hunnit ikapp VR-teknologin. Verkar vara roligt Jag kände inte att det gav så mycket, så under hela sessionen undrade jag vad jag skulle med detta till. It is full of possibilities, but still awe and a little scary ;) Det är coolt, men jag vet inte riktigt vad jag ska göra med det. Fun to play around in and it has great potential to prosper in the field of gaming but also in other fields such as healthcare, economics, educational systems and such. It seems to enhance the experience of digital games, and I think it's an interesting technology. Because is a new way to visit places also to play and even it can be use as a powerful tool for architects, artists and designers Havent try Ointresserad It is new and has many possibilities I'm interested in technological features in general, and I also studied VR at the university in some courses. Spännande. Tänker vilka möjligheter som finns med denna teknik. I wanted to pick emoji nr. 11, but that radio button was not available. Anyhow, to the question: VR is cool, but also make me a bit sick. Furthermore I don't like the fact that you isolate yourself from the people around you (with the current applications that I know of) while experiencing VR. I like to be more social. Pretty cool tech. Too early to be amazing yet. Sounds like an entertaining way to interact with the virtual world. Intresserad men skeptisk Dont know Många möjligheter till nya upplevelser Exciting, want to try. Cool new technology.	A pretty amazing technology that opens up new user experience possibilities It's not mature yet, could be cool but needs better quality imo As a gamer VR makes it possible get even more emerged in the fantastic work and wild imagination created by other people. It's still in a gimmick phase - a cool gimmick - but I'm not sure how it will develop. It's a paradigm shift in the way we view, see and interact Im entering a different world and it feels real and the instant reaction is wow. Det är coolt men jag får lite ont i ögonen och blir lite illamående Such a different experience compared to anything else. So much potential for the future that it feels like a paradigm shift and it is cool to be an early adopter being part of that transformation. its the future My expectations before trying VR was a bit too high. The current technology is a bit limited. It's mind bending Excitement is temporary. Too much work and yeah not really convenient! Many VR applications that I've seen could have been done better without the VR. People are using VR just because they want to use VR, not because they wanted to use the most suitable technology and it turned out to be VR. Exciting It's exciting and new, a format and scene Im not used to. very neat and fun experience, growing field and will be fun to see where it leads. A bit to pricy for a decent set especially considering supported Products are few and limited thus far. **Cool=9** **Future&possibilities=6** **A gimmick=4** **Meaningful content=3**	Regarding why they feel this way is generally said to be due to the potential the VR technology brings, as well as it is cool and interesting. However, they also question VR in terms of meaningful content and usefulness, and also that it is a bit in gimmick mode with a bit of a hassle to it. A small group of individuals also expresses more negatively put concerns about VR. This comes in terms of that it is anti-social, scary and that they hope it will not change the way we live by turning too big. Some of these also says that they already think we spend a lot of time looking into our smartphones, and that they do not want VR to add more to this.

	At first I was amazed by virtual reality. Now when I have more experience, faults with the available technology makes it less interesting to use. Especially the low resolution and not seeing your own body, as well as unaccessible and ungainly devices. I still think virtual reality has great potential, but for now I'm patently waiting for the next generation devices to hit the market. Spännande teknik, skulle vilja testa på det. Spännande att se hur VR kommer att utnyttjas i framtiden. exciting and endless of possibilities both in work and play ... **Future&possibilities=11** **Interesting=8** **Cool=7** **Meaningful content=5** **Hassles=4** **Fun=4** **No motivation=3** Isolating/antisocial=2 For games=2 Nothing new=2 Motion sickness=1 Scary=1 Uninterested=1	**Hassles=3** Fun=2 For games=1 Motion sickness=1 Pricey=1 Interesting=1	
If you were to use VR, in what context would you feel comfortable/uncomfortable when using it?	**Alone:** 19 comfortable (76%), 6 uncomfortable (24%) **Family:** All comfortable **Friends:** All comfortable **Colleagues:** 22 comfortable (88%), 3 uncomfortable (12%) **Strangers:** 9 comfortable (36%), 16 uncomfortable (64%)	**Alone:** 15 comfortable (93,75%) and 1 (6,25%) uncomfortable **Family:** All comfortable **Friends:** All comfortable **Colleagues:** All comfortable **Strangers:** 11 comfortable (68,75%) and 5 uncomfortable (31,25%)	Most say that they feel comfortable in most contexts, however using VR with strangers is something that sticks out as being perceived as uncomfortable where approximately half of all responders has assigned this as uncomfortables. Also, using VR alone is also put as uncomfortable, where 17% finds this uncomfortable. It is important to consider that it might be difficult to assess how they would feel in these situations by asking them, and a more though assessment of this would be done by actually observing people in this situations. However, it gives a hint about what people feel about VR and during which situations when they are not using VR perceive as uncomfortable versus comfortable, as they will bring this thoughts into the use.
Which of these use areas do you think that you would	**Entertainment 96%** **Education 88%** **Business, science and industry 64%** **Real-estate previews 56%** **Healthcare, theraphy and rehab 52%** **Social functions 32%** Travelling 24% Shopping and other consumer activities 16%	**Entertainment 93,8%** **Education 81,3%** **Business, science and industry 75%** **Healthcare, theraphy and rehab 62,5%** **Real-estate previews 43,8%** **Social functions 43,8%** **Work-out and well-ess 43,8%** **Travelling 43,8%**	Entertainment, education, business science and industry strikes high for all, where almost everyony wants to use VR for entertainment I particular. This might be due to that this is primairy what VR is used for right now. As for the

be most interested in using VR for?	Work-out and well-ess 12% Other: 4% (artistic representations)	Shopping and other consumer activities 18,8% Other: 12,5% (the limit is our creativity)	other parts, these are highly functional use areas, rather than semi-entertaining experiences as e.g. shopping or travelling might be viewed upon as. However, most use areas generally score high in interest, indicating the futuristic approach of VR.
What are your expectations on the future role of VR?	it is here to stay, will be more useful and easier to use. Yttligare en spelplattform/tillbehör till plattformar. Komplement i utbildningar. Vet ej Inga alls, tror det kan bli svårt att få ut det till användning av den stora massan. It will become a means to explore things not yet existing or too far away. If we just get vr for haptics we will be able to simulate anything, being on the moon, being a dinosaur etc Jag hoppas att det kan vara en användbar teknik som kan göra saker smidigare och underlätta, typ spara in onödiga resor till något ställe. an every day tool such as Laptop, smartphones, PC etc. I think it will develop, but I hope it won't take over from other experiences as well. Is the future of many jobs and also is the future of entertainment Used in more daily developments in compaines Underhållning I hope it will be implemented in "useful" ways and not only for entertainment. I believe VR will be a key element in future technology together with AR Att det kommer vara en naturlig del av vår vardag. I think that the VR world will have to become more social. The trend has been in the opposite direction for many years, with people spending more time with their phones than the people around them. Big expectations. Game industries and a way to depict 3D structures in a more pedagogical way than what would be achieved on a 2D screen. e.g. 3D protein structures. Hoppas att det kan användas som ett hjälpverktyg - Att tekniken kommer att utvecklas och användas inom många olika områden i framtiden Add on to existing technology. Gaming, consumption websites and visualisation I think VR will have an important role in society in the future, but I do not believe it will be something people use in everyday activities. In VR you travel to an alternative reality, and I don't think you have	I have particular faith in VR related education in relation to car safety and similar features. I think it will deliver in the future Hopefully we will get "streamed" real time VR with high visual fidelity in a near future (near as in 5-10 years). Which would open up for a much much wider audience and richer experiences. Unsure we've only just scratched the surface To reach a similar flexibility like for smartphones, tablets, laptops accessible for everyone. Att det ska kännas nästan lika verkligt som verkligheten. Att det kanske kan hjälpa oss att förstå andra kulturer och delar av världen bättre. Become cheaper, easier to use, more like reality with graphics and tactile experiences and more part of everyday life. it'll take get a bigger place As the hardware improves the importance of VR will increase. VR will have new uses that hasn't been invented yet. In the long run it's gone change how it is to be human Will suit the gaming, healthcare and entertainment industry more. AR will have a more mainstream impact in user friendliness and convenience. I think that people abuse the technology for things that it's not supposed to be used for. Just like touch screens when they were popularized. Hopefully this trend will turn soon so that people focus on more practical applications instead of just applications that look cool. More fun. To be more educational, and less 'gimmicky'. Supply and demand will lead to cheaper tech which will in turn lead to more Products being developed. Will not replace TV and computers but provides a new tool to the table just as tablets have done. **We can do anything/It is the future = 6** **It will be more useful and easier to use = 4** **Needs more use areas/reach more people = 3** **Better/realer = 3** **Everyday use = 3** *Hope it will be more useful than now = 2* *Hope it will not only be for entertainment = 2* *It is for gaming/entertainment = 2* *Cheaper = 2*	The expectations of the future role of VR follows the same patterns as previously seen, which wraps up how VR is perceived by this target group. VR is highly futuristic and there are high expectation on everyday useage and general functionality. However, the also expresses needs of that it needs more functionality, quality and general improvements. Lastly, some are expressing more negatively expectations, either that it is "just another gaming thing" and needs to be less gimmicky to actually happen and not be misused as a technology, but also that they hope it will not break through.

	reasons to do that on an everyday basis. But still, it will have impact in some way... Svårt att säga men tror det kommer vara mer inkluderat i ens vardag. Tror det har stor potential i utbildningssyfte. Hade varit coolt att använda VR för att skissa modeller istället för CAD. To be a substitute too many flat screens ... **Everyday use = 10** **We can do anything/It is the future = 9** **For work, business, professional = 6** **It will be more useful and easier to use = 5** **It is for gaming/entertainment = 5** I do not know = 4 It is here to stay = 3 Complement to education = 2 Travel/explore=2 *More use areas/reach more people = 1* *Hope it will not stay = 1* *Hope it will be more useful = 1* *Hope it will not only be for entertainment = 1*	*For work, business, professional = 1* *Complement to education = 1* *Travel/explore=1* *Unsure = 1* *It might be misused = 1*	
	Real life experiences		
Describe a situation in real life when you feel confident?	**When being the expert of the area and knowing that you are good at this = 13** **With family/friends = 6** **At work/school = 5** **Chilling home = 3** Getting good feedback = 2 I am always confident = 2 When well prepared/planning=2 Making people laugh/feel good = 1 Driving = 1 Doing hobby = 1	**When being the expert of the area and knowing that you are good at this = 7** **Doing hobby = 5** **Familiar situation = 4** **Chilling home = 3** **With family/friends = 3** **Knowing what is expected = 3** At work = 2 Succeeding/overcoming challenges = 2	This target group feel confident when the feel like they are the expert in the area and either knows that they are good at this or get feedback that they are good at this. Furthermore, knowing what is expected or familiarity also is a criterion for confidence. Additionally, being with family and friends and relaxing at home is said to be circumstances that makes them confident.
Describe a situation in real life when you feel unconfident?	**In a unknown territory of knowledge or experience = 12** **Talking with unknown people = 6** **Not understanding social reactions or being included in social situations = 5** **Leaving comfort zone = 3** **Not in control = 3** Want to contribute but cannot or do not know how = 2 Talking in front of people = 2 Do not know = 2 New places = 2 Unprepared=1 Work=1 Heights=1 Failing = 1 Dark passage = 1 Being laughed at = 1	**In a unknown territory of knowledge or experience = 4** **Talking with unknown people = 4** **Leaving comfort zone = 3** **New places = 3** Talking in front of people = 2 Being questioned = 1 Pushing myself = 1 Work = 1 Exams = 1 Do not know = 1 Never happens = 1	Territories where knowledge and experience is lacking are situations that means unconfidence. This also has to do with the other circumstances of unconfidence, as talking with new people and not understanding the social situation one is in. Similarly, new places, not having control and generally leaving the comfort zone by e.g. doing things that are new or perceived unpleasant are circumstances of uncomfort for this.
Describe a situation in real life when you feel relaxed?	**At home/in sofa = 12** **Finished working/end of the day = 6** **With friends/family = 6** **Spare time, weekends, travelling = 5** **Reading = 4** In nature = 2 Finished task = 2 Massage = 1 Nothing planned = 1 Hobby = 1 Quiet moment = 1 Doing daily chores = 1	**At home/in sofa = 8** **With friends/family = 3** **In bed = 3** Shower/spa/well-ness = 2 Spare time, weekends, travelling = 2 Hobby = 1 Finished working/end of the day = 1 Turning off focus = 1	Similar to the situation of confidence, the situations where people are relaxed are at home and with friends and family. Also leisure time, relaxing in any way and finishing the day are thing that makes people relaxed.
Describe a situation in real life when you feel stressed?	**Too much to do = 12** **Deadlines = 9** **Too late (and the threat of it) = 5** **Uncontrollable = 4** Social difficult situations = 3 Quarrels = 2 Do not know how to solve problems = 2 The bus (in time) = 2 Traffic = 2 Disrupted when doing important things = 1 Big crowds of people = 1 I do not get stressed = 1	**Deadlines = 5** **Too much to do = 8** **Too late (and the threat of it) = 3** Stakes are high = 2 Traveling = 2 Failing = 1 Big crowds of people = 1 Talking with new people = 1 Traffic = 1 Work = 1	The other way around to when you feel relaxed, people feel stressed when there is too much to do too soon, and generally the threat of time hoovering over you. Additionally, various social situations elicits stress, such as quarrels, crowds, being questioned, new or tricky people.
Describe a	**With family/friends = 9** **Doing the hobby = 6**	**With family/friends = 9** **Doing hobby = 5**	In relation with confidence and relaxed, they feel happy

situation in real life when you feel happy?	**Done something good/pays off = 4** Making others happy/helping = 3 Nature = 2 No musts = 1 Doing things I thought I could not do = 1 Meeting new people = 1 When confident and relaxed = 1	Being active = 2 Nature = 2 A fresh start = 2 Done something good/pays off = 1 Small highlights of the day = 1 When feeling included in a group (of positive energy) = 1 Creativity = 1 No answer = 1	when being with family and friends, performing the hobby and generally receiving any feedback that makes them feel good about themselves.
Describe a situation in real life when you feel scared?	**Dark places = 6** **Never feel scared = 5** **Feeling unsafe = 4** **People close to me in danger/dying = 4** Not in control and not knowing what is going on = 3 Alone = 3 In deep water = 2 Crisis situations = 2 Judged by others = 2 Horror movies (do not like it) = 2 Failure = 1 Unpredictable and unreliable people = 1 Surprise = 1 Conflicts = 1 Heights = 1 Spiders/frogs etc. = 1	**Horror movies (do not like it) = 3** People close to me in danger/dying = 2 Crisis situations = 2 No answer = 2 Dark places = 1 Conflicts = 1 Judged by others = 1 Not in control and not knowing what is going on = 1 Heights = 1 Around ghosts = 1 Feeling unsafe = 1 Difficult challenges = 1 Nightmares = 1 Surprise = 1	Situations when people explicitly feel scared are being in dark places, feeling unsafe in any way and the threat of people close to you being hurt or dying. Some also assign horror movies and similar as where they feel scared, adding that they do not like it for this purpose. Similar to situations of stress, one might feel scared as a response to social situations, e.g. being judged by others, conflicts or generally being in the presence of others they perceive as unreliable or unpredictable.
		Experiences of the feet	
Are there any feet experiences which you find unpleasant? Why?	**Injuries and abrasions = 6** **Wet/dirty grounds = 5** **Tickles = 4** **Wet shoes socks/shoes = 4** **No/do not know = 4** Too cold/warm = 3 Standing for too long/restless feet = 2 Sliding downwards = 1 Assessed distance to the ground wrong = 1 Too heavy feet = 1 Foot massage = 1 Smelly feet = 1	**Wet/dirty grounds = 4** **Tickles = 3** **Nothing = 3** Injuries and abrasions = 2 Uncertainty of what is walked upon = 1 No answer = 1 Others hairy feet = 1 Standing for too long/restless feet = 1 Slippery grounds = 1 Not seeing where the feet is put = 1 Assessed distance to the ground wrong = 1 Smelly feet = 1 Narrow high bridges = 1	Feet-wise unpleasant experiences are characterized by, except by obvious painful experiences, also grounds that are dirty, crumbly, wet and sticky, and particularly the combination of these altogether. Many also perceive tickles as unpleasant. Other things that are perceived as unpleasant by a smaller group is generally uncertainty of what is felt or the consequence of uncertainty to what is felt.
Are there any feet experiences which you find pleasant? Why?	**Smooth/soft materials with analogy to it = 9** **Massage = 7** **Heat = 4** **Freedom feels = 4** **Do not know = 4** Caresses people = 2 Swimming = 1 Walking in cold water = 1 Taking off the shoes = 1 Firm ground with sound = 1 Pressure = 1	**Smooth/soft materials with analogy to it = 8** **Massage = 5** **Heat = 4** Swimming = 2 Nothing = 2 Having use of the feet = 1 Taking of the shoes = 1 Caresses people = 1	Pleasant feet experiences are, except obvious things as massage, smooth and soft experiences. Also these most often these are such that has some analogy or association to them, e.g. a notion of freedom, summer, vacation or cozyness.
Are there any experiences to your feet that you usually avoid? Why?	**Injuries/abrasions/too small shoes = 8** **Cold and wet = 6** **No = 6** **Being barefoot outside = 4** Tricky socks = 2 Too hot = 2 Dirty materials = 1 Without socks = 1 Ticklings = 1 Slippery materials = 1 Wet socks = 1	**Being barefoot outside = 6** **Injuries/abrasions/too small shoes = 6** **No = 3** Heights = 2 Nothing = 2 Unstable grounds = 1 Ticklings = 1 Too hot = 1 From water to sand = 1	Related to what is perceived as unpleasant, people avoid these experiences consequently. Also being barefoot outside is also avoided, even though many expressed being barefoot as being plesant. This is said to be due to the inlearnt threat of stepping on something unpleasant and due to not being used to being barefoot.
Approximately, how much time per day do you spend on your feet? (Standing up, walking and running)	<1h = 1 (4%) 1-2h = 4 (16%) 2-3h = 10 (40%) 3-4h = 3 (12%) 4-5h = 3 (12%) 5-6h = 2 (8%) 6-7h = 0 7+h = 2 (8%) Median = 2-3h Mode = 2-3h Variation width = 7	<1h = 0 1-2h = 3 (18,8%) 2-3h = 4 (25%) 3-4h = 4 (25%) 4-5h = 3 (18,8%) 5-6h = 1 (6,3%) 6-7h = 0 7+h = 1 (6,3%) Median = 3-4h Mode = 2-3&3-4h Variation width = 7	About 3 hours a day, plus minus one hour, is generally how much time that is spent on the feet as in standing up, walking and running.
How much time would you like	<1h = 0 1-2h = 1 (4%) 2-3h = 2 (8%) 3-4h = 8 (32%) 4-5h = 6 (24%)	<1h = 0 1-2h = 0 2-3h = 4 (25%) 3-4h = 5 (31,3%) 4-5h = 1 (6,3%)	About 4 hours a day, plus minus one hour is generally how much time that they want to spend on the feet as in standing up, walking and

to spend on your feet? (Standing up, walking and running)	5-6h = 1 (4%) 6-7h = 4 (16%) 7+h = 3 (12%) Median = 4-5h Mode = 3-4h Variation width = 6	5-6h = 1 (6,3%) 6-7h = 2 (12,5%) 7+h = 3 (18,8%) Median = 3-4h Mode = 3-4h Variation width = 5	running. This might be translated to that people generally want to spend more time on their feet, but not too much more and not as the greatest part of their waken time.
Draw to mind a case where you used your feet to investigate an object or ground surface. What was it and why did you do it?	**Investigate and understand materials and objects = 10** **Do not know = 7** **Find way when sight is limited/darkness = 5** **Offering the foot rather than the whole body = 5** **Get grip/be stable = 4** **Investigate water temperature = 4** Touching nice/feeling good materials = 3 Icky things = 3 Reaching for things = 2	**Investigate and understand materials and objects = 7** **Offering the foot rather than the whole body = 7** **Find way when sight is limited/darkness = 5** **Reaching for things = 4** **Icky things = 4** **Get grip/be stable = 3** No answer = 2 Investigate water temperature = 2 Touching nice/feeling good materials = 1	Except obvious facts as being stable and holding a grip (which is more important in some situations than others), the feet is generally used to investigate and understand materials and objects placed on the ground, furthermore using the foot in a rather "sacrificing" manner. This is due to that they rather sacrifices the foot first to understand what is to expect, rather than risking the whole body or more important parts. Similar, the feet are used to find the way when sight is limited or when it is dark. A conclusion might therefore be drawn that the feet are important as we have learnt to investigate some thing with the feet, as they are sensitive but not as sensitive as other parts. Therefore, they might be put at risk investigating some ground properties without risking other more vital functions of the body. As for some cases, the feet more suitable to use, e.g. investigating objects that actually are placed in foot height or stability.

Appendix 11

Test procedure

Procedur användartest VR

1. Ta av skor och strumpor samt ha hyffsat rena fötter.

2. FRÅGA: Är det ok att filma?

3. Får ej se testbanan! Blunda när personen går in, och ställ sig med ryggen mot banan.

4. Introducera till uppgiften:

Varför just foten?

- Nu ska ska du får göra ett test i VR som gäller fotens känselintryck i virtuella miljöer.
- Varför foten? Foten är hela tiden i kontakt med vår omvärld och ger oss information.
- Fotens känselupplevelser är väldigt viktiga för hur vi uppfattar saker, t.ex. balans.
- Därför är det viktigt att man för bättre VR upplevelser inkluderar detta, i och med att det bidrar till att skapa det vi upplever som närvaro i en situation.

Uppgiften:

- Du ska få gå igenom en liten fot-hinderbana i VR.
- Poängen; få veta hur det känns att upplever olika typer av känselintryck med foten i VR.
- Därför får du inga handkontroller.
- Tänk högt och säg hur det känns när du upplever olika saker – ingen feedback är dålig feedback!

5. Fyll i **del 1** av enkät

6. Sätt på kameran och Viven – fortfarande med ryggen emot.

7. Vänd sig om och börja testet!

8. Genomförande

	Variant 0	Variant 1	Variant 2
Ser	VR-miljö	VR-miljö	VR-miljö
Känner	Inget	Realistisk feedback	Modifierad feedback
Metod	Gå igenom miljön utan haptisk feedback	Gå igenom miljön med haptisk feedback	Gå igenom miljön med haptisk feedback
Utvärdera	Hur man reagerar på vad som ser ut som haptiska förändringar när det inte finns några.	Hur upplevelsen förändras med haptisk feedback: -Hur känns det att uppleva detta i VR? -Vad är bra/dåligt? -Vad ger störst/mist utslag? -Vad är nyttan? -Varför och när ska man känna?	Hur upplevelsen förändras med haptisk feedback: - Hur känns det att uppleva dessa sensationer? -Hur noggrannt känner vi? -Kan man luras och ge en annan känselupplevelse men det känns ändå samma? -Vad betyder känslan?

9. Ev. fyll i **del 2** av enkät

10. Intervjudel.

Vad tyckte du om de olika delarna?

Hur verkligt kändes det?

Var något extra behagligt eller obehagligt?

Vill man ha detta till Vr upplevelser?

Extra för Variant 2:
Hur skillde det?
Var någon upplevelse tillräcklig/otillräcklig?

Appendix 12

Test survey

Survey VR test

Answer in Swedish or English.

*Obligatorisk

Before test

1. **Age?** *

2. **Have you tried VR before this test?** *
   Markera endast en oval.
   - Yes
   - No

3. **Rate: How excited are you before testing this out?** *
   Markera endast en oval.

	1	2	3	4	5	6	7	8	
Not excited									Very excited

4. **Rate: How nervous are you before testing this out?** *
   Markera endast en oval.

	1	2	3	4	5	6	7	8	
Not nervous									Very nervous

After test

5. **Rate: How excited were you when actually in VR?** *
   Markera endast en oval.

	1	2	3	4	5	6	7	8	
Not excited									Very excited

6. **Rate: How nervous were you when actually in VR?** *
   Markera endast en oval.

	1	2	3	4	5	6	7	8	
Not nervous									Very nervous

7. **Evaluate: What part(s) of the experience felt most realistic?** *
   Markera alla som gäller.
   - The fire
   - The step
   - The water
   - The grass
   - The stone
   - The board
   - The snow
   - Övrigt:

8. **Evaluate: What part(s) of the experience felt most unrealistic?** *
   Markera alla som gäller.
   - The fire
   - The step
   - The water
   - The grass
   - The stone
   - The board
   - The snow
   - Övrigt:

9. **Evaluate: What part(s) of the experience did you find most pleasant?** *
   Markera alla som gäller.
   - The fire
   - The step
   - The water
   - The grass
   - The stone
   - The board
   - The snow
   - Övrigt:

10. **Why?**

11. **Evaluate: What part(s) of the experience did you find most unpleasant?** *
    Markera alla som gäller.
    - The fire
    - The step
    - The water
    - The grass
    - The stone
    - The board
    - The snow
    - Övrigt:

12. **Why?**

13. **If feet experiences like these was possible to be given to VR, is there anything about it you would like to comment?**

Appendix 13

Result of the test surveys for Part 1 and Part 2

Part 1 – Realistic haptic feedback

Category	Result
Age	28,28,32,33,34,36 "The 40" is now "the 34", meaning a with less experience of VR and not testing part 2.
VR experience	Everyone assigned that they have tried VR before this test (but some and especially one expresses little experience since only once and long-time ago tried mobile VR).
Excitement before	5,5,7,8,8,8. Median= 7,5. Mode= 8. Variation width= 3. Excited or very excited, meaning high expections on what is supposed to be experienced in the VR test.
Excitement during (retrospect evaluation)	4,5,6,7,7,7. Median= 6,5. Mode= 7. Variation width= 3. Less excited but still excited when testing, meaning that that expectations was in some ways met, but not entirely however not fully contradicted.
Nervousity before	1,2,2,2,3,7. Median= 2. Mode= 2. Variation width= 6. In general not very nervous before, however there are exceptions. Might be due to not knowing what to expect. Especially the person with less experience had very high nervousity before.
Nervousity during (retrospect evaluation)	1,1,2,2,6,8. Median= 2. Mode= 1&2. Variation width= 7. Most seem to be less nervous however some seem to be even more nervous when in in VR. Might be due to that the impressions made some user even more unsure about what to expect while others was made more certain about their expectations. However, the person with less experience had maximized nervousity during.
Questions	Answer
What part(s) of the experience felt most realistic?	Fire=1. Step=4. Water=4. Grass=1. Stone=2. Board=4. Snow=1. Other=1. Many agree on realistic: step, water and board. Fewer agree on realistic: stone Not agree on what is the most realistic. Means that the evaluation of what is realistic is based on things which differs from person to person.
What part(s) of the experience felt most unrealistic?	Fire=4. Step=0. Water=1. Grass=0. Stone=3. Board=0. Snow=3. Other=0. Many agree on unrealistic: fire, stone and snow. Agrees more upon what is unrealistic, very determined answer. The things that was most difficult to simulate accurate are more easily established as unrealistic, even though some think these are sufficiently realistic.
Evaluate: What part(s) of the experience did you find most pleasant?	Fire=3. Step=1. Water=2. Grass=2. Stone=1. Board=1. Snow=2. Other=0. Fewer (but most) agree on pleasant: fire. Even fewer: water and grass.
Why?	"safe Den var ju först, och en av de kraftigare. Värmen/kylan mot fötterna var go Behagliga, kända underlag som man ofta går barfota i/på och därför inte så rädd för överraskningar" When it is safe, known and feeling what is known as nice skin sensations is pleasant. Powerful experiences might be interpreted as pleasant as well to some.
What part(s) of the experience did you find most unpleasant?	Fire=0. Step=1. Water=4. Grass=0. Stone=0. Board=1. Snow=1. Other=1. Many agree on unpleasant: water.
Why?	"I got surprised when i stepped in water and got my feet wet didn´t expect that För att det inte var fejk, som jag tycker att det borde vara i VR. dealen är att allt är fejk, tycker jag. Kändes lite halkigt att gå på Läskigt med höjdskillnad och ostabilitet när man inte ser just VAR man sätter foten eller hur det rör sig för att hålla balansen" Surprise and material properties which are associated with uncertainty of balance or unpleasantness. Too realistic might also provide unpleasantness, as a reaction to surprise.
If feet experiences like these was possible to be given to VR, is there anything about it you would like to comment?	"It would be beautiful, maybe even better if I saw some actual feet in VR mode Jag skulle vilja kunna se mina ben/fötter samt armar för att bättre känna stabilitet och balans Hade varit najs om fötterna syntes så som händerna gör iom att man hålelr i kontrollerna. Nu väntar man hela tiden på att de ska dyka upp från glasögonkanten." Visual feet in VR is desired!

Conclusion	High expectations before, and still excited when in even though the expectations were not fully fullfilled. Some people react nervously to this input, some do not. What is perceived as most realistic is "floating", however what is not is easier to agree upon. What was perceived as most unrealistic was those properties that was most difficult to simulate accurate. Furthermore, also these ones generate a more active thinking about the properties as for fire and snow. This means that what is realistic is floating, but what is unrealistic are those that we actively think about due to kind of object or object haptics insufficiency. Pleasantness are generally properties related to values that are pleasant, either physical sensations, inlearnt or metaphorical. Same goes the other way around, though highly related to uncertainty rather than actual danger. Many explicitly expressed that the feet are missing.

Part 2 – Modified haptic feedback

Category	Result
Age	28,29,32,33,36,40 "The 34" is now "the 40", meaning a person without reference to part 1.
VR experience	Everyone assigned that they have tried VR before this test (but some expresses little experience).
Excitement before	3,5,6,6,6,8 Median= 6. Mode= 6. Variation width= 5. Less excited than part 1 but still excited. Might be due to better knowing what to expect from the VR experience, yet still excited since the experiences proved to be exciting for part 1.
Excitement during (retrospect evaluation)	3,4,4,5,6,7 Median= 4,5. Mode= 4. Variation width= 4. Less exciting when testing, both in camparision with assigned excitement before testing as well as in comparision to part 1. Also more in agreement about this being less exciting.
Nervousity before	1,1,2,2,2,4 Median= 2. Mode= 2. Variation width= 3. About the degree of very low nervousity, however no one describing explicit nervousity. Probabaly due to knowing what to expect.
Nervousity during (retrospect evaluation)	1,1,1,1,3,5 Median= 1. Mode= 1. Variation width= 4. Not nervous at all, however the new testperson with no reference to part one expressed more nervousity, which also increased a tad in relation to what was felt before.
Questions	Answer
What part(s) of the experience felt most realistic?	Fire= 0. Step=1. Water=0. Grass=2. Stone=0. Board=5. Snow=0. Other=0. Many agree on realistic: board. Fewer agree on realistic: grass. Agrees on what is perceived as realistic, however the grass is perceived different. The board was most accurate to the visuals and to the day before, which could be a reason to this. The test person that not tested part 1 assigned the grass and the board as most realistic. So why the grass is realistic could also be due to degree of previous reference but also generally due to that people associate things differently.
What part(s) of the experience felt most unrealistic?	Fire= 4. Step=1. Water=3. Grass=1. Stone=2. Board=1. Snow=6. Other=0. Everyone agrees on unrealistic: snow. Many agree on unrealistic: fire and water. Fewer agrees on unrealistic: stone. Agrees upon what is unrealistic, very determined answer. The things that was most difficult to simulate accurate are more easily established as unrealistic. No difference for the test person who did not experience part 1.
Evaluate: What part(s) of the experience did you find most pleasant?	Fire= 1. Step=2. Water=0. Grass=3. Stone=0. Board=2. Snow=0. Other=0. Most agree on pleasant: grass. Fewer agree on pleasant: board and step.
Why?	"mysig badrumsmatta :) It felt soft under my feet and the boards texture was nice and somewhat realistic mest intressant, starkast känslor." Feeling nice to skin (and what is was really) was pleasant. Providing most interesting feedback could also be interpreted as pleasant. No difference for the participant that did not attend part 1.
What part(s) of the experience did you find most unpleasant?	Fire= 0. Step=4. Water=0. Grass=0. Stone=1. Board=1. Snow=1. Other=0. Many agree on unpleasant: step.
Why?	"height difference as big as that is a weird experience to handle in vr/reality combined Inte alls i rätt höjd, inte alls mjuk och fluffig Hard to keep balance when you cant see your feet, arms or body in relation to the ground if became unpleasant when it just was the floor. I expected it to be something more because last time it was more of a experience Höjdskillnaden lurade ögat men inte hjärnan och krocken mellan dom kändes konstig. För att syn och känsel säger olika saker." (Expected) difference in levels and hardness is weird as it makes less sense and mismatches the expectations, which leads to feeling of unpleasantness. Balance problems due to this and not

	seeing your foot, which is unpleasant. No difference for the participant that did not attend part 1.
If feet experiences like these was possible to be given to VR, is there anything about it you would like to comment?	"it has to be really good to improve the overall experience (in most cases). Gårdagens tillförde ngt till upplevelsen, idag var det inte tillräkligt verklighetstorget för att det skulle tränga in i vr utan jag sorterade bort intrycken no Not like this, it doesnt add anything really, but the last test, that adds! depends on context. Ok for home use, not commercial, expo things etc." When it is not enough for the experience is does not mean anything or does not improve the experience. It was not sufficient. Compares to part one and says that that one complements. Could be ok for homeuse, someone says. However, the test person that did not attend part one did not add anything about this.
Conclusion	The excitement before testing was lower than for part one, and especially when in the experience. This was also true for the nervousity. In general this seem to be due both knowing what to expect when in but also that part 2 was perceived as less realistic than part 1. This is also proven by the test person whom had not tested part one which was much more excited and nervous before. Regarding realisticness was the haptics with most similar properties perceived as most realistic, however also seem to has to do with personal associations and previous experience and disappointment. When it comes to unrealisticness, it was seen again that the objects that generate level/hardness and active thinking which where the objects that was perceived as most unrealistic. Suck properties as therefor tricky to get away with. Pleasantness was again what is nice according to physical sensations, about also how intruiging the experienced turned with haptics. Unpleasantness however was when expectations was not met, and escpecially for levels (and hardness) since this led to weird emotions. Many added that weird/insufficient feedback does not do the trick for the experience.

Appendix 14

Digitalized KJ-matrix of test result

Part 0

Category	
Strange test	It feels weird to walk through an obvious test site when there is nothing there and nothing different haptic to evaluate.
Level differences	Walking through level changes in particular is strange since this sensation depends on actually perceiving changes in levels.
The surfaces feels the same	All surfaces feels the same haptically.
…except fire	The fire is however a bot different since it also has the hinder of being scary to walk through.
Sensations that matches the floor that is walked upon is ok	
Small steps and tension	Have not seen before what is walked upon leads to small steps and tension, as one usually sees what the test site looks like before entering any VR experience.
No expectations	As there was nothing in the fire, nothing was further expected in terms of haptics
Confident and carefree	As there is nothing in the way, the test site is over all passed with confidence and carefreeness.

Part 1 and 2

Category	Description	Learnt how
Intrinsic rules of the users interaction		
Intrinsic rules of interaction	The users created intrinsic rules about how they should treat and respond the environment when it included haptic responses.	From comparing differences in interactions for the same experience in Part 1 as for Part 2.
Expecting over all consistency	When some haptic feedback is given in VR, the users expect consistency in the performance of this haptic feedback throughout the experience-	
Broken intrinsic rules means extra time is needed	When the intrinsic rules of interaction are broken, it takes more time for the users to perform the interaction due to them investigating what haptic feedback to expect before interacting.	
Disappointment when unsatisfactory degree of haptic feedback	If the given haptic feedback is evaluated as unsatisfactory for the experience in relation to what has been perceived early, the users will be put negatively.	
Certain properties are taken for granted	Differences in levels and hardness in combination with visual perception of the position in haptic medium that are definied by this (e.g. the pile of snow or the step) are not the properties that yielded most attention when given, but the ones most missed when not offered.	
Dominating the attention means that the haptic feedback does not have to be exact	When the overall experience dominates over the impression of the feet, the haptic feedback does not need to be exact. This could be seen for e.g. the warm fire, where many users often was so intrigued by that they were going to walk through fire and probably feel warmth that the exactness and performance was not in center of the evaluation.	
The more attention and importance that is put on the haptics, the more exactness is needed	The other way around to the previous, the more possibilities the user is given to evaluate the haptic feedback as well as the more important it is for the experience, the more exactness is needed in its performance.	
The users learn and change their ways of interaction	When the users has learnt what to expect, they will change their behavior accordingly e.g. avoid scary thing or move quicker through the environment	
User interpretations due to offering haptics to visual stimuli		
If it does not look right to the user, the haptic feedback does not make it any better		
If it does not look right to the user, the feedback was associated with other things		
Associations	Depending on what haptic experiences that are given to the visuals in VR, the evaluation of what is perceived changed	
It feels good when the expectations are met		
It is unnerving to do real life dangerous things		
It is pleasant to do things associated with security and familiarity		
The whole concept of touching in VR is unpleasant		
Providing "just some" haptic feedback is not enough	Though the given haptic feedback does not have to be exact to real life one, just giving some haptic feedback seemed not to	

	generally do the trick either without investigating what the haptic feedback meant for the experience.	
User differences		
Users perceive measurable things different	The users evaluated fixed and measurable properties differently, most often in terms of width and positions of the source of the haptics.	
Differences for unexperienced user		
Differences for user with no comparision to previous experience		
User actions due to offering haptics to visual stimuli		
Sacrifices the foot	Similarly to the Survey 2 result, the test showed that people tend to investigate things perceived as scary or suspicious with the foot first, e.g. the fire and what temperature to be expected.	
Wants to establish global haptic relations	It was common that the users wanted to establish a relation between the objects, how they felt and was positioned in relation to each other.	
Exploration phase to create familiarity	When haptic information was given to the VR experiences, some time was spent on exploring and thinking about these sensations. This was partly a result to the design of the test, but also a part of the user creating its intrinsic rules.	
Waiting in preparation with performing interactions when haptic feedback is expected		
Actively faking their real life movements		From Part 1 when the overall experience engaged into actions, and Part 2 when insufficient feedback was provided.
Surprise and uncertainty in interactions	When knowing that haptic feedback is to be expected the users tend to be easier surprised and uncertain, leading to them being more careful.	
Outspoken considerations		
"Wow"-sensations	All users expressed some kind of "wow-feelings" to when haptic feet feedback was offered to the VR experience. Most of these Wow-feelings was however declining with time, as they were a reaction to being able to do something they never experienced before.	
Discussing possibilities in terms of functionality and usefulness	Some individuals expressed things related to what might be done with these, spanning from questioning the purpose to finding functionality.	
Missing feet	All users explicitly expressed that they missed seeing their feet in VR. As a consequence they experienced big difficulties with their balance, aiming their feet and understand their position in relation to haptic experiences which should deform beneath them.	
Missing hands and body		
It offers more interesting experiences		
It is an odd experience		
Comfortable haptic feedback means being friendly and kind	Sensations related to comfort was by some user expressed as making the experience of the feedback more friendly and kind.	
Actively revealing how the haptic feedback means negativity for the experience or unsatisfied user	Assessing and figuring out how the haptic feedback was actually composed was in particularly noticed when the users clearly could feel that the haptic feedback was not right or clearly were the same for feet experiences that should be haptically different. It could also happen when the user was already disappointed or when this haptic experience in particular was an disappointment to earlier experiences. Furthermore, this lead to actively unmasking the experience in a negative manner for the total experience.	
VR should not be realistic	Some users expressed explicitly that VR is not supposed to feel realistic, or that they do not expect the experiences to be real. This due to that there is a perception of VR promising a deal that it feels near reality, while it is not actually real. If it would be real, it is not entirely sure it would be interesting or useful.	
If VR is to be realistic, information about this is wanted	Consequently, if the VR experiences is supposed to feel real some users explicitly expressed that they want warnings of what to expect when in VR before entering.	
Post-VR emotional reactions	Some users expressed post-VR emotions, in terms of how boring the real world is or exhaustion from all the impressions (for the unexperienced user).	

Appendix 15

Expression board describing the current VR products

High tech for the future urbans

Used pictures:

Shape: https://www.polygon.com/2016/10/13/13246682/playstation-vr-review [Retrieved 2017-05-10]

Color and material: https://www.vive.com/us/product/ [Retrieved 2017-05-10]

Metaphor: https://futurism.com/teslasuit-full-body-suit-lets-feel-virtual-reality/ [Retrieved 2017-05-10]

Functionality:https://www.google.se/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwi-nq2t3oHVAhUFJ5oKHQIgCiEQjxwIAw&url=http%3A%2F%2Fwww.pcworld.com%2Farticle%2F2947483%2Fgadgets%2Fwhy-oculus-radical-fantastic-touch-vr-controller-should-ship-with-the-rift.html&psig=AFQjCNEomNq9aRmbP_IRCrbsvtmy0WYgWA&ust=1499879849282720[Retrieved 2017-05-10]

Master of Science Thesis PPUX05

Enhancing Virtual Reality experiences with feet haptics
Master of Science Thesis in the Master Degree Program, Industrial Design Engineering

Chalmers University of Technology
SE 412 96 Gothenburg, Sweden
Phone +46 (0) 31 - 772 1000

Cover photo: Felicia Ränge
Print: Repro Service Chalmers

CHALMERS UNIVERSITY OF TECHNOLOGY
SE 412 96 Gothenburg, Sweden

Phone: +46 (0) 31 - 772 1000
Web: www.tekniskdesign.se